CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
3550 N. Central Ave, 2nd floor
Phoenix, AZ, 85012
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

Notice of Mining Location Virginia

LODE CLAIM

TO ALL WHOM IT MAY CONCERN:

This Mining Claim, the name of which is the Snake Pit

Mining Claim, situate on Lands belonging to the United States of America and in which there are valuable mineral deposits, was entered upon and located for the purpose of exploration and purchase by

Marshia Searle and Adele Gifford

Citizens of the United States

(Locator must either insert "a citizen of the United States," or "who has declared his intention to become a citizen of the United States")

the undersigned, on the 17th day of February 1981

The length of this claim is 1500 feet

and We claim 1140 feet feet

in a Northerly direction and

360 feet in a Southerly direction

from the center of the discovery shaft, at which this notice is posted, lengthwise of the claim, together with

300 feet in width of the surface grounds

on each side of the center of said claim. The general course of the lode deposit and premises is from the

South to to the North or Northeasterly Direction.

The claim is situated and located in the Weaver Mining District

in Mohave County, in the State of Arizona about 25 Miles

in a Northerly direction from Chloride, Arizona

in Section 22 T.26 N., R.21 W.

The surface boundaries of the claim are marked upon the ground as follows: Beginning at

A monument a 4"X4" Post

at a point in a Southerly direction 360 feet from

the discovery shaft (at which this notice is posted), being in the center of the South

end line of said claim, thence 300 feet to a 4"X4" Post, being the

S.E. corner of said claim; thence 1500 feet to a 4"X4" Post

being at the N.E. corner of said claim; thence 300 feet to a

4"X4" Post at the center of the

North end of said claim; thence

300 feet to a 4"X4" Post,

being at the N.W. corner of said claim;

thence 1500 feet to a 4"X4" Post

at the S.W. corner of said claim; thence

300 feet to the place of beginning.

Dated and posted on the grounds, this 17 day of

February 1981

Marshia Searle

Adele Gifford

BOOK 691 PAGE 752

Excerpts From the Mining Laws of the State of Arizona

TITLE XXXIV of the Revised Statutes of 1913

4029. Such location shall be made by erecting at or contiguous to the point of discovery a conspicuous monument of stones not less than three feet in height, or an upright post, securely fixed, projecting at least four feet above the ground, in which monument of stones or on which post there shall be posted a location notice which shall be signed by the name or names of the locator or locators.

4030. From the time of the location of a mining claim, as above specified, the locator shall be allowed ninety days within which to do [illegible] cause to be done the following things:

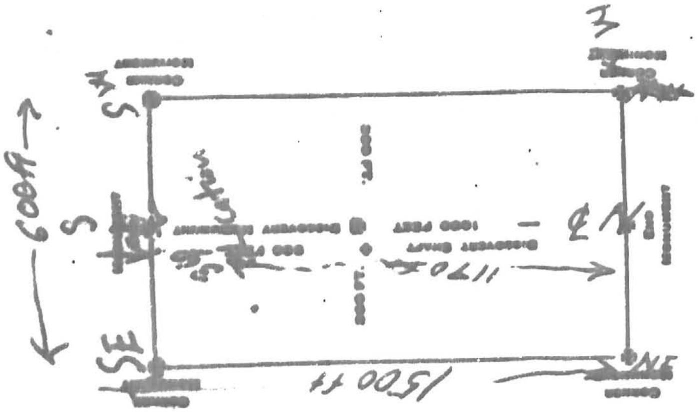
(1) To cause to be recorded in the office of the county recorder of the county in which the claim is situated a copy of the location notice;

(2) To sink a discovery shaft in the claim to a depth of at least eight feet from the lowest part of the rim of the shaft at the surface, and deeper, if necessary, until there is disclosed in said shaft mineral in place;

(3) To monument the claim on the ground so that its boundaries can be readily traced.

4033. Any open cut, adit or tunnel which shall be made as above provided for, as a part of the location of a lode mining claim, and which shall be equal in amount of work to a shaft eight feet deep and four feet wide by six feet long, and which shall cut a lode or mineral in place at a depth of ten feet from the surface, shall be equivalent, as discovery work, to a shaft sunk from the surface.

4034. Location notices may be amended at any time and the monuments changed to correspond with the amended location; provided, that no change shall be made that will interfere with the rights of others.



Return to Adele Gifford Desert Sunset Motor Court,
3535 Chino Drive G.V.
Kingman, Arizona 86401

INDEXED MINES
INDEXED PROOFED
81-5346

FEE NO. ________

RECORDED AT REQUEST OF Joe Barnes

DATE FEB 17 1981 -10 40 AM IN BOOK 691 of OFFICIAL RECORDS

PAGE (S) 752-753 RECORDS OF MOHAVE COUNTY, ARIZONA.

RETURN:

JOAN McCALL, RECORDER
by K. Pemberton
$ 3.00

BOOK 691 PAGE 753

Notice of Mining Location

LODE CLAIM

TO ALL WHOM IT MAY CONCERN: A MC 89702

This Mining Claim, the name of which is the C-6 RELOCATION

Mining Claim, situate on lands belonging to the United States of America and in which there are valuable mineral deposits, was entered upon and located for the purpose of exploration and purchase by CHARLES R. KUNKES AND WIFE M.V. KUNKES ARE CITIZEN OF THE U.S.

(Locator must either insert "a citizen of the United States," or "who has declared his intention to become a citizen of the United States")

the undersigned, on the 12 day of AUGUST, 1980

The length of this claim is 1500 feet

and WE claim 1480 feet

in a NORTHERLY direction and

20 feet in a SOUTHERLY direction

from the center of the discovery shaft, at which this notice is posted, lengthwise of the claim, together with 300 feet in width of the surface grounds on each side of the center of said claim. The general course of the lode deposit and premises is from the NORTH to the SOUTH

The claim is situated and located in the WEAVER Mining District in Mohave County, in the State of Arizona about NEXT in a NORTHERLY direction from LIBERTY MINE

THE Claim is IN T 22 N R 21 W

27|28

31|32

The surface boundaries of the claim are marked upon the ground as follows: Beginning at LOCATION MONUMENT

at a point in a SOUTHERLY direction 20 feet from the discovery shaft (at which this notice is posted), being in the center of the SOUTH end line of said claim, thence 300 feet to a POST, being the S.E corner of said claim; thence 1500 feet to a POST, being at the N.E corner of said claim; thence 300 feet to a POST at the center of the NORTH end of said claim; thence 300 feet to a POST, being at the N.W corner of said claim; thence 1500 feet to a POST at the S.W corner of said claim; thence 300 feet to the place of beginning.

SEP 5 1972

BOOK 45 PAGE 376

Dated and posted on the grounds, this 12 day of AUGUST, 1980.

Charles R. Kunkes

Marguerite V. Kunkes

BOOK 652 PAGE 904

Excerpts From the Mining Laws of the State of Arizona

TITLE XXXIV of the Revised Statutes of 1913

4028. Such location shall be made by erecting at or contiguous to the point of discovery a conspicuous monument of stones not less than three feet in height, or an upright post, securely fixed, projecting at least four feet above the ground, in which monument of stones or on which post there shall be posted a location notice which shall be signed by the name or names of the locator or locators.

4030. From the time of the location of a mining claim, as above specified, the locator shall be allowed ninety days within which to do or cause to be done the following things:

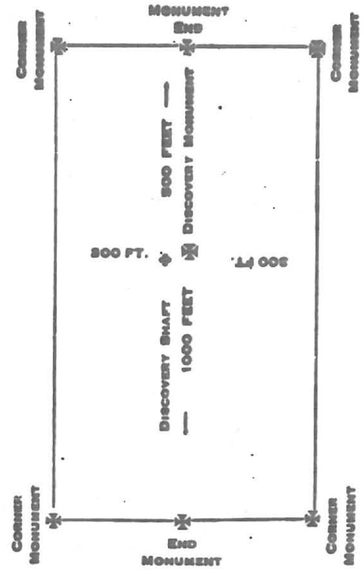
(1) To cause to be recorded in the office of the county recorder of the county in which the claim is situated a copy of the location notice;

(2) To sink a discovery shaft in the claim to a depth of at least eight feet from the lowest part of the rim of the shaft at the surface, and deeper, if necessary, until there is disclosed in said shaft mineral in place;

(3) To monument the claim on the ground so that its boundaries can be readily traced.

4033. Any open cut, adit or tunnel which shall be made as above provided for, as a part of the location of a lode mining claim, and which shall be equal in amount of work to a shaft eight feet deep and four feet wide by six feet long, and which shall cut a lode or mineral in place at a depth of ten feet from the surface, shall be equivalent, as discovery work, to a shaft sunk from the surface.

4034. Location notices may be amended at any time and the monuments changed to correspond with the amended location; provided, that no change shall be made that will interfere with the rights of others.



This diagram is to give locator a general idea of plan of location under the law. The discovery shaft can be in the center of the claim or any distance from either end desired. In the diagram it is placed 500 feet from one end and 1,000 feet from the other. Commence description of claim at a center end monument, giving its distance and direction from center of discovery; thence bound the claim in either direction. In description be careful to state locality of claim with reference to some natural object or permanent monument as will identify the claim.

STATE OF ARIZONA }
County of ______________ }

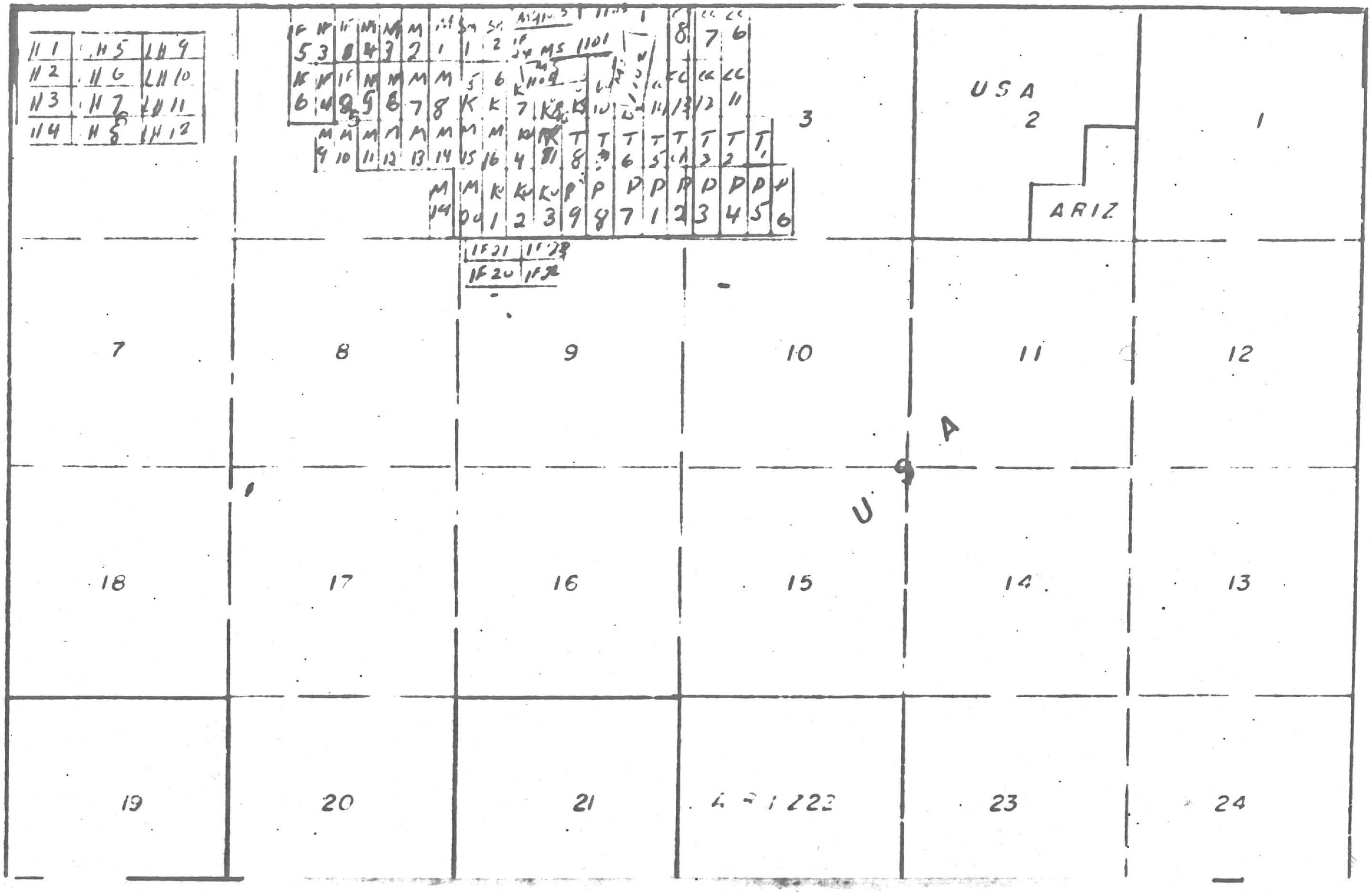
I, ______________ County Recorder in and for the County and State aforesaid, do hereby certify that the within instrument was filed for record at ________ o'clock ______ m., on this ______ day of ______________ 19____, and duly recorded in Book No. ________ of ________ Records of ______________ County, Arizona, at Pages ________.

WITNESS my hand and official seal the day and year first above written.

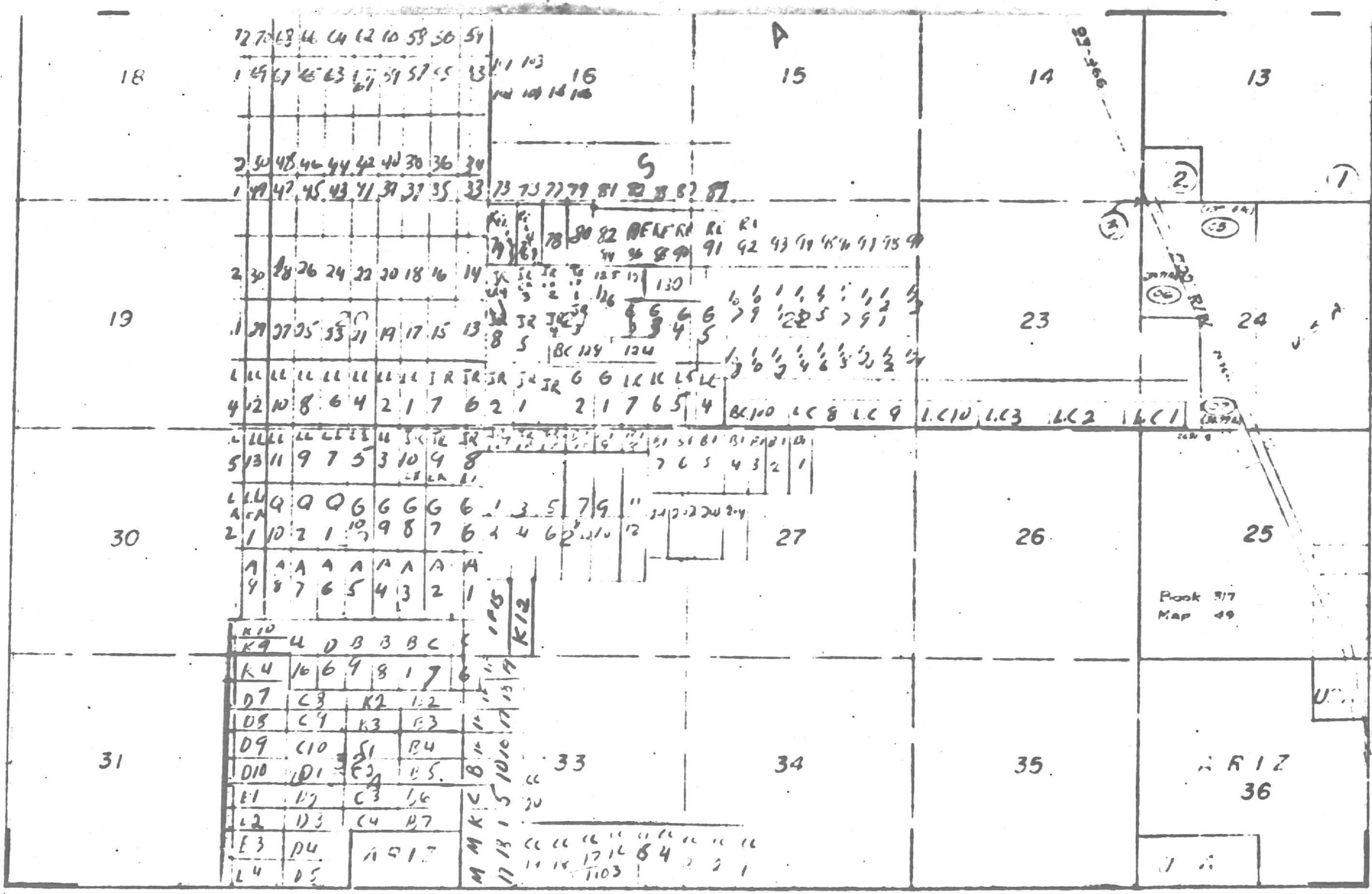
____
County Recorder

BOOK 652 PAGE 905

TOWNSHIP 26N RANGE 21W



BOOK 652 PAGE 906



BOOK 652 PAGE 907

MOHAVE C

27 N-21W

Rit L V S R
Box 970, Kingman Az 86401

PROOFED INDEXED MINES

FEE # 80-27601 INDEXED

Recorded at the Request of C. L. Kuenke

on AUG 21 '80 - 8 00 AM

in Book 652 of OFFICIAL RECORDS,

Page(s) 904-908,

Records of Mohave County, Arizona.

Joan McCall

Mohave County Recorder

By [signature]

Deputy

3 00

Virginia

AMENDED

Notice of Mining Location

LODE CLAIM

TO ALL WHOM IT MAY CONCERN:

This Mining Claim, the name of which is the MOCKING BIRD No. 1 Mining Claim, situate on lands belonging to the United States of America, and in which there are valuable mineral deposits, was entered upon and located for the purposes of exploration and purchase, in compliance with the local laws, customs, rules and regulations, by NEALY WHITE

(Locator must insert either "a Citizen of the United States", or "who has declared his intention to become a citizen of the United States")

the undersigned, on the 17th day of DECEMBER, 1969.

The length of this claim is 1500 feet, and I claim 122 feet in a NORTHERLY direction and 1378 feet in a SOUTHERLY direction from the center of the discovery shaft, at which this notice is posted, lengthwise of the claim, together with 300 feet in width of the surface grounds, on each side of the center of said claim. The general course of the lode deposit and premises is from the NORTH to the SOUTH

The claim is situated and located in the WEAVER Mining District, in Mohave County, in the State of Arizona, about 26 miles in a northwesterly direction from CHLORIDE, ARIZONA in section 22 - T26N - R21W

The surface boundaries of the claim are marked upon the ground as follows: Beginning at a monument of stone and wood which is the NORTH end center and at a point in a NORTHERLY direction 122 feet from the discovery shaft (at which this notice is posted), being in the center of the NORTH end line of said claim; thence 300 feet to a monument, being the NE corner of said claim; thence 1500 feet to a monument, being at the SE corner of said claim; thence 300 feet to a monument at the center of the SOUTH end of said claim; thence 300 feet to a monument, being at the SW corner of said claim; thence 1500 feet to a monument at the NW corner of said claim; thence 300 feet to the place of beginning.

All done under the provisions of the Revised Statutes of the United States, and of Acts of the Legislature of Arizona. This further and amended notice of location is made without waiver of any previously acquired rights, but for the purpose of correcting any errors or defects or omissions in the original location, description, or record and to secure all the benefits of said section of said Civil Code.

THIS AMENDED LOCATION is made in conformity with the original location, made by W. H. HALL recorded JANUARY 4, 1932 in Book 3N of Mines, Page 351 in the office of the Recorder of said County, and it is made for the purpose of appropriating all ground within the boundaries hereinbefore described, and of more definitely describing the situation and boundaries of said lode, correcting any irregularities, informalities or errors, supplying omissions, and correcting any defects which may have existed in the original location, or the record thereof, hereby waiving no rights acquired under and by virtue of said original location. And if the original location or the certificate thereof is void, then this location shall be an original location and this certificate an original certificate.

Date of Original Discovery OCTOBER 12, 1931

Date of Amended Location DECEMBER 17, 1969

Witness:

George C. [illegible]

Nealy White

337

AMENDED

Notice of Location

LODE CLAIM

Dated ...., 19....

Filed and recorded at request of

............, A. D. 19....

at .... o'clock .... M.

Book ....

Pages ....

County Recorder

By ....

Deputy Recorder

Docket No. ....

When recorded, please mail this instrument to

Recorded at Request of Geo[illegible] Castle

DEC 19 1969 ______ Min. Past 12 o'clock ______ M.

in book 6-S of MINES, Pages 237 - 238

Records of Mohave County, Arizona. Peggy B. Smith

By ______________ Deputy Recorder ______________ Recorder

2.00

Geo Del
Kingman, Ariz

INDEXED

72564

AMENDED

Notice of Mining Location

LODE CLAIM

TO ALL WHOM IT MAY CONCERN:

This Mining Claim, the name of which is the MOCKING BIRD No. 2 Mining Claim, situate on lands belonging to the United States of America, and in which there are valuable mineral deposits, was entered upon and located for the purposes of exploration and purchase, in compliance with the local laws, customs, rules and regulations, by NEALY WHITE

(Locator must insert either "a Citizen of the United States", or "who has declared his intention to become a citizen of the United States")

the undersigned, on the 17th day of DECEMBER, 1969.

The length of this claim is 1500 feet, and I claim 235 feet in a WESTERLY direction and 1265 feet in an EASTERLY direction from the center of the discovery shaft, at which this notice is posted, lengthwise of the claim, together with 300 feet in width of the surface grounds, on each side of the center of said claim. The general course of the lode deposit and premises is from the EAST to the WEST

The claim is situated and located in the WEAVER Mining District, in Mohave County, in the State of Arizona, about 26 MILES in a NORTHWESTERLY direction from CHLORIDE, ARIZONA in section 22-T26N-R21W

The surface boundaries of the claim are marked upon the ground as follows: Beginning at A monument of stone and wood which is the WEST end center and at a point in a WESTERLY direction 235 feet from the discovery shaft (at which this notice is posted), being in the center of the WEST end line of said claim; thence 300 feet to a monument, being the NW corner of said claim; thence 1500 feet to a monument, being at the NE corner of said claim; thence 300 feet to a monument at the center of the EAST end of said claim; thence 300 feet to a monument, being at the SE corner of said claim; thence 1500 feet to a monument at the SW corner of said claim; thence 300 feet to the place of beginning.

All done under the provisions of the Revised Statutes of the United States, and of Acts of the Legislature of Arizona. This further and amended notice of location is made without waiver of any previously acquired rights, but for the purpose of correcting any errors or defects or omissions in the original location, description, or record and to secure all the benefits of said section of said Civil Code.

THIS AMENDED LOCATION is made in conformity with the original location, made by W. H. HALL recorded JANUARY 3, 1932, in Book 3-N of Mines, Page 352 in the office of the Recorder of said County, and it is made for the purpose of appropriating all ground within the boundaries hereinbefore described, and of more definitely describing the situation and boundaries of said lode, correcting any irregularities, informalities or errors, supplying omissions and correcting any defects which may have existed in the original location, or the record thereof, hereby waiving no rights acquired under and by virtue of said original location. And if the original location or the certificate thereof is void, then this location shall be an original location and this certificate an original certificate.

Date of Original Discovery OCTOBER 12, 1931

Date of Amended Location DECEMBER 17, 1969

Witness:

George C. Castle

Nealy White

AMENDED

Notice of Location

LODE CLAIM

Dated ...., 19......

Filed and recorded at request of

..........................., A. D. 19.........

at ....o'clock.........M.

Book............................

Pages............................

County Recorder

By..

Deputy Recorder

Docket No..................

When recorded, please mail this instrument to

Recorded at Request of George C. Caistle

DEC 19 1969 ______ Min. Past 12:00 o'clock ____ M.

in book 6-S of MINES ____________ Page s 239 - 240

Records of Mohave County, Arizona. Peggy B. Smith

Peggy B. Smith

By ________________ ________________

Deputy Recorder Recorder

2 —

INDEXED

72565

AMENDED

Notice of Mining Location

LODE CLAIM

TO ALL WHOM IT MAY CONCERN:

This Mining Claim, the name of which is the MOCKING BIRD No. 5 Mining Claim, situate on lands belonging to the United States of America, and in which there are valuable mineral deposits, was entered upon and located for the purposes of exploration and purchase, in compliance with the local laws, customs, rules and regulations, by NEALY WHITE

(Locator must insert either "a Citizen of the United States", or "who has declared his intention to become a citizen of the United States")

the undersigned, on the 17th day of DECEMBER, 1969

The length of this claim is 1500 feet, and I claim 208 feet in a WESTERLY direction and 1292 feet in an EASTERLY direction from the center of the discovery shaft, at which this notice is posted, lengthwise of the claim, together with 300 feet in width of the surface grounds, on each side of the center of said claim. The general course of the lode deposit and premises is from the EAST to the WEST

The claim is situated and located in the WEAVER Mining District, in Mohave County, in the State of Arizona, about 26 miles in a northwesterly direction from CHLORIDE, ARIZONA in section 22-T26N-R21W

The surface boundaries of the claim are marked upon the ground as follows: Beginning at a monument of stone and wood which is the WEST end center and at a point in a WESTERLY direction 214 feet from the discovery shaft (at which this notice is posted), being in the center of the WEST end line of said claim; thence 300 feet to a monument, being the NW corner of said claim; thence 1500 feet to a monument, being at the NE corner of said claim; thence 300 feet to a monument at the center of the EAST end of said claim; thence 300 feet to a monument, being at the SE corner of said claim; thence 1500 feet to a monument at the SW corner of said claim; thence 300 feet to the place of beginning.

All done under the provisions of the Revised Statutes of the United States, and of Acts of the Legislature of Arizona. This further and amended notice of location is made without waiver of any previously acquired rights, but for the purpose of correcting any errors or defects or omissions in the original location, description, or record and to secure all the benefits of said section of said Civil Code.

THIS AMENDED LOCATION is made in conformity with the original location, made by W. H. HALL recorded January 4, 1932, in Book 3 N of Mines, Page 355 in the office of the Recorder of said County, and it is made for the purpose of appropriating all ground within the boundaries hereinbefore described, and of more definitely describing the situation and boundaries of said lode, correcting any irregularities, informalities or errors, supplying omissions and correcting any defects which may have existed in the original location, or the record thereof, hereby waiving no rights acquired under and by virtue of said original location. And if the original location or the certificate thereof is void, then this location shall be an original location and this certificate an original certificate.

Date of Original Discovery OCTOBER 27, 1931

Date of Amended Location DECEMBER 17, 1969

Witness: George C. Cort[illegible]

Nealy White

AMENDED

Notice of Location

LODE CLAIM

Dated ...., 19....

Filed and recorded at request of

................, A. D. 19....

at .... o'clock .... M.

Book ....

Pages ....

County Recorder

By ....

Deputy Recorder

Docket No. ....

When recorded, please mail this instrument to

Recorded at Request of George C. Castle

DEC 19 1969 ——— Min. Past 12 o'clock ——— M.

in book 6-S of MINES ——————— Pages 241 - 242

Records of Mohave County, Arizona.

Peggy B. Smith

By ——————— ———————

Deputy Recorder Recorder

2.00

INDEXED

72566

PLAT

Mocking Bird

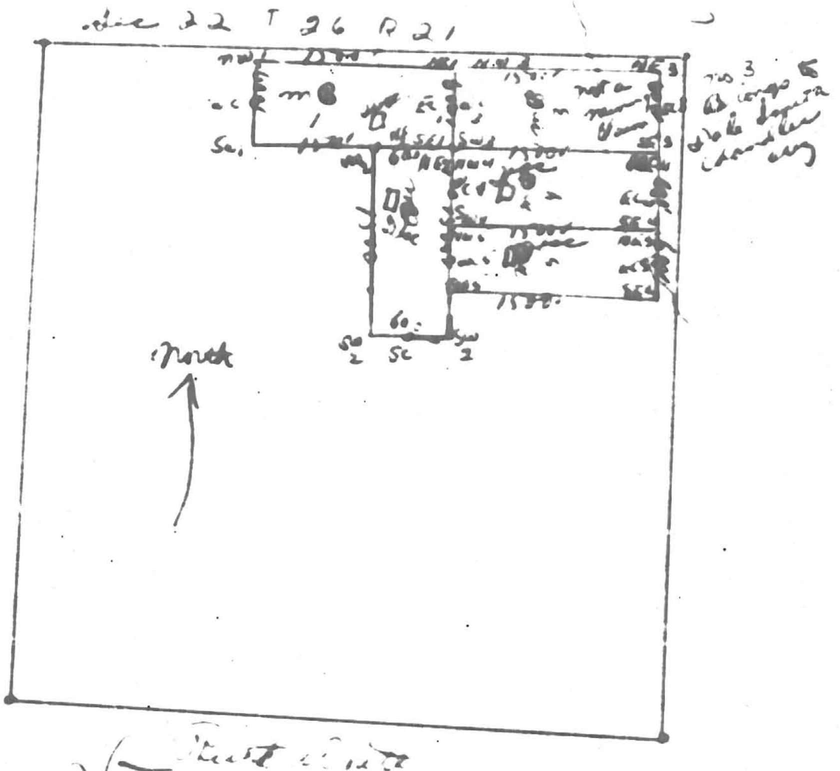
AMC 80711 thru AMC 80714

1-2 4-5

12-27 Oct 1931

Book 3 of mines Pg 351 to 355

Sec 22 T 26 R 21



Ruth White
PO Box 67
Chloride Ariz
86431

1200 ft
1 inch

INDEXED

FEE # 80-34277 PROOFED

Recorded at the Request of Ruth White

on OCT 16 '80 - 1 50 PM

in Book 664 of OFFICIAL RECORDS,

Page(s) 697

Records of Mohave County, Arizona.

Mohave County Recorder

By Clarann Case
Deputy

2.50

STATE OF ARIZONA) SS.
COUNTY OF MOHAVE)

ACKNOWLEDGED before me this 16 day of October 1980 by Ruth White

Clarann Case
Notary Public

Affidavit of Labor Performed and Improvements Made

Mailing address Clayton L Stewart Box 44 Sun Valley, Idaho 83353

STATE OF ~~Arizona~~ IDAHO, } ss.
County of ~~Mohave~~ BLAINE

Clayton L Stewart being duly sworn, deposes and says that he is a citizen of the United States and more than twenty-one years of age, and resides at 1200 Canyon Run Blvd, Ketchum in Blaine County, State of ~~Arizona~~ IDAHO, and is personally acquainted with the mining claims known as

MOCKING BIRD #1	Book 6 S	Page 237 + 238
MOCKING BIRD #2	Book 6 S	Page 239 + 240
MOCKING BIRD ~~#3~~ #4	Book 3-M	Page 354
MOCKING BIRD #5	Book 6 S	Page 241 + 242
	Book	Page
	Book	Page
	Book	Page
	Book	Page
	Book	Page

mining claims, situate in WEAVER Mining District, County of Mohave, State of Arizona; that between the FIRST day of SEPT A. D. 1979, and the 31ST day of AUGUST A. D. 1980, at least Four Hundred dollars worth of work and improvements were done and performed upon said claim, not including the location work of said claim. Such work and improvements were made by and at the expense of George C. Castle & Clayton L Stewart owners of said claim for the purpose of complying with the laws of the United States pertaining to assessment of annual work and George Castle, & Clayton Stewart ~~were the men employed by said owners and~~ who labored upon said claim, did said work and improvements, the same being as follows, to-wit: drilling test holes 200 feet deep - drilling - blasting etc

Clayton L Stewart

Subscribed and sworn to before me this 26th day of August, A. D. 1980

T K Ehrenberg
Notary Public

(My commission expires 1982

Filed and recorded at request of Clayton L. Stewart
AUG 29 '80 - 8 00 AM, A. D. 19__, at __ o'clock __ M., Book __ PROOFED
~~Proof of Labor~~, pages 636, Records of Mohave County, Arizona.
IN BOOK 654 of OFFICIAL RECORDS
JOAN [illegible]
County Recorder 300
By [illegible signature] Deputy Recorder
Page

80-28536 INDEXED
INDEX P of L

BOOK 654 PAGE 636

Notice of Mining Location

A. CARLISLE & CO., UPHAM & RUTLEDGE, INC., S. F. 40644

LODE CLAIM

TO ALL WHOM IT MAY CONCERN:

This mining Claim, the name of which is the Mocking Bird No. 4 Mining Claim, situate on lands belonging to the United States of America, and in which there are valuable mineral deposits, was entered upon and located for the purpose of exploration and purchase by W. H. Hall

a Citizen of the U.S.A.

(Locator must insert either "a citizen of the United States," or "who has declared his intention to become a citizen of the United States.")

the undersigned, on the 27th day of Oct, 1931.

The length of this claim is 1500 feet, and I claim 1300 feet in a Easterly direction and 200 feet in a Westerly direction from the center of the discovery shaft, at which this notice is posted, lengthwise of the claim, together with 300 feet in width of the surface grounds, on each side of the center of said claim. The general course of the lode deposit and premises is from the Easterly to the Westerly.

The claim is situated and located in the Weaver Mining District, in Mohave County, in the State of Arizona, about 26 Miles in an No.Westerly direction from The Town of Chloride.

The surface boundaries of the claim are marked upon the ground as follows: Beginning at a Monument of Stone

at a point in a Westerly direction 200 feet from the discovery shaft (at which this notice is posted), being in the center of the Westerly end line of said claim; thence Northerly 300 feet to a Monument, being the No. Westerly corner of said claim; thence Easterly 1500 feet to a Monument being at the No.Easterly corner of said claim; thence Southerly 300 feet to a Monument at the center of the Easterly end of said claim; thence Southerly 300 feet to a Monument being at the So.Easterly corner of said claim; thence Westerly 1500 feet to a Monument at the So.Westerly corner of said claim; thence Northerly 300 feet to the place of beginning.

Dated and posted on the ground, this 27th day of Oct., 1931.

Witness

John H. Ware

W. H. Hall

Filed and recorded at request of W. H. Hall this 4 day of Jan., 1932, at 3 o'clock P. M., in Book 3N at Page 354.

Mary E. Carrow
County Recorder.

By
Deputy Recorder.

LF

DOC- 2

PAGE- 17

Economic Geology
Vol. 83, 1988, pp. 551–567

Relationships between a Porphyry Cu-Mo Deposit, Base and Precious Metal Veins, and Laramide Intrusions, Mineral Park, Arizona

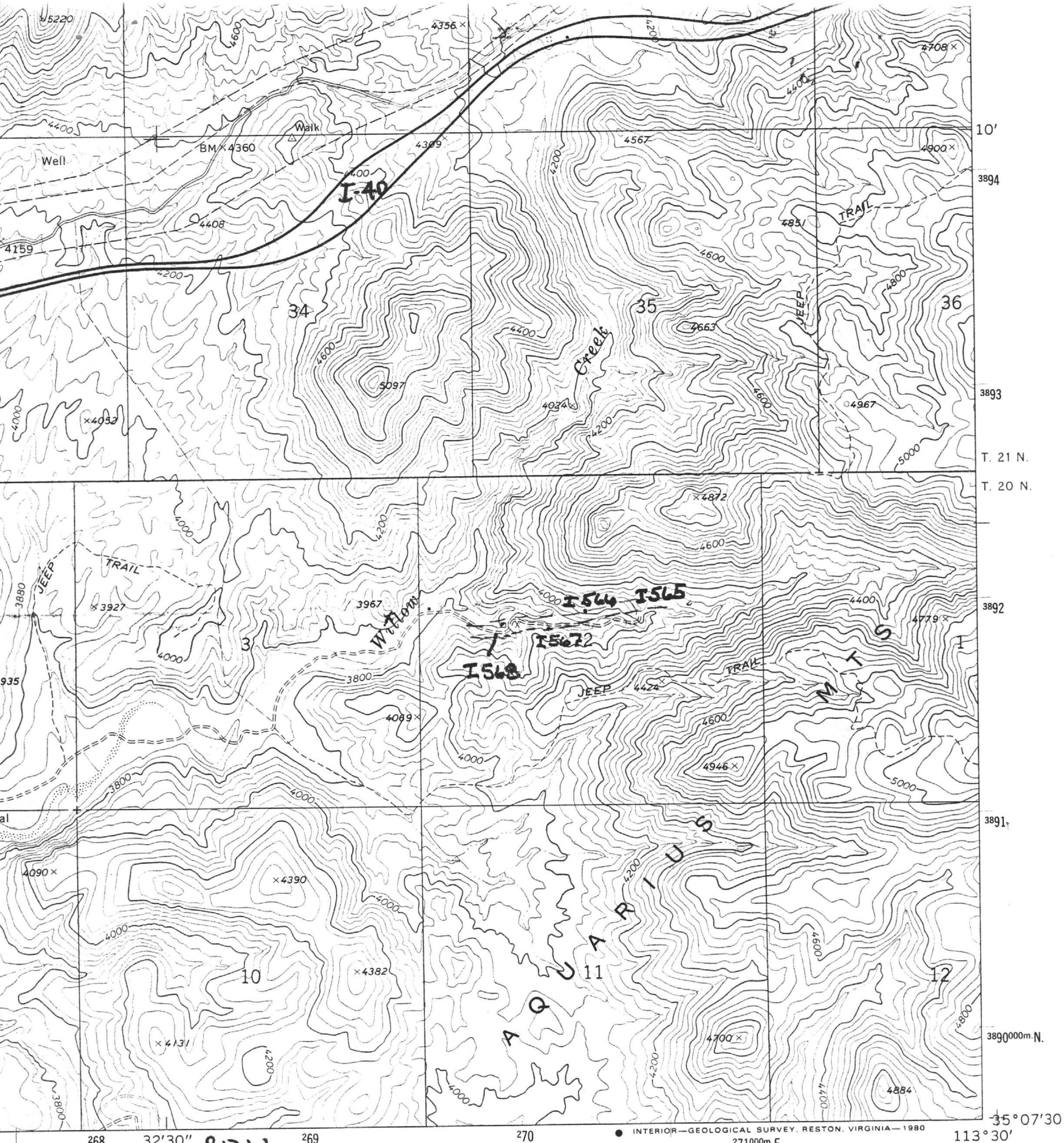
0361-0128/88/804/551-17$2.50

From: WSD
To: GAP
Concern: Rucker Barite property, Mohave Co., Arizona

This property was examined for its precious metal value; while it is valueless for these metals, its barite potential may be of interest to NICOR.

This property exploits a steeply dipping, probably stratiform, zone in PCb-age amphibolitic schists and gneissic granitic rocks. Ninety tons of barite have been produced from a zone roughly 20 feet wide; barite is present in both siliceous and argillic zones for at least 1000 feet along strike.

One sample of barite obtained from the property gave a specific gravity of between 4.35 and 4.48. Two valid unpatented claims cover some of the barite ground.



1 MILE

7000 FEET

OMETER

ROAD CLASSIFICATION

Heavy-duty .... Light-duty ....

Unimproved dirt

Interstate Route

ARIZONA

QUADRANGLE LOCATION

TIN MOUNTAIN, ARIZ.

N3507.5—W11330/7.5

property file JB

DEPCO, Inc.

MINERALS DIVISION

DATE: January 13, 1981

MEMO TO: J. B. Imswiler

FROM: N. L. Archbold

SUBJECT: Reconnaissance of Some Districts in the Northern Black Mountains, Mohave County, Arizona

Districts Included: Eldorado Pass, Gold Bug, Mocking Bird, and Pilgrim.

Maps and References:
Mount Perkins 15' and White Hills 15' Quadrangles.
USGS Bulletin 397, p. 214-218.
Arizona Bureau of Mines Bulletin 137, p. 78-80.

General Types of Deposits:

1) Gold and silver in narrow veins cutting Precambrian gneiss.
2) Precious metals associated with lamprophyre.
3) Veins and stockworks in Tertiary volcanic rocks associated with Tertiary volcanic intrusions.

Notes on My Examinations: (see numbers on accompanying Mt. Perkins 15' Quadrangle).

Eldorado Pass District

1) ×Enigma Mine - narrow vein in Precambrian granite. Strikes N 60° W about vertical.
2) Nearly vertical vein in unaltered granite. Strikes about N 80° W.
3) Old mill site and Pope #1 location. Vein in Precambrian granite gneiss. Strikes about N 35° E and dips steeply NW. Looks like some attempt at leaching in recent years.

4, 5, & 6)
Broader zone of iron staining and brecciation related to flat (?) structure. This area might be worth mapping and sampling if my samples show any values.

SAMPLE	Au (ppm)	Ag (ppm)
H-14 - Portal of tunnel at northeast end of area. Sheared, argillized and slightly iron-stained granite.	-.1	-1
H-15 - Portal of tunnel about 1000 feet SW of H-14. Brecciated, iron-stained and argillized granite.	-.1	-1
H-16 - Dump at road intersection about 1000 feet SW of H-15. Brecciated, argillized and hematite-stained granite with some veinlets of hematite.	1.1	2

7) Prospects in hematite-cemented pediment gravels with some secondary

390 FREEPORT BLVD. • SUITE 12 • SPARKS, NEVADA 89431 • (702) 359-3211

copper minerals. This makes me wonder what lies below the gravels?

8) Vertical shaft in brecciated, altered, apparently barren granite.

SAMPLE	Au (ppm)	Ag (ppm)
H-17 - Brecciated, iron-stained granite with silicification, argillization, and serifitization.	-.1	-1

My general impression is that there is little probability of an important deposit in the Eldorado Pass area. Closer examination of the area in the SW ¼ of sec. 17, T. 27 N., R. 21 W. might be advisable. The gravels here suggest the possibility of a pyritic, disseminated-type of deposit (porphyry copper?) in the area.

Gold Bug District

9) Van Deemen Mine - This looks like an intrusive mass of Tertiary andesite into the Precambrian gneiss with abundant brecciation, iron oxides and argillization. I noted some veinlets of gypsum. There appear to have been countless shallow drill holes and samples taken by some small operator. There is a small dump set out on a makeshift leach pad. The area should be looked at more closely if my two samples from the dump show ore-grade values of gold or silver.

SAMPLE	Au (ppm)	Ag (ppm)
H-18 - Brecciated, iron-stained, and argillized gneiss and andesite off one side of small leach dump.	6.0	9
H-19 - From other side of same dump as H-18.	.7	3

10) Liberty Mine - Brief underground examination indicates small stope on structure that strikes WNW with dip to N. Structures are narrow and in brecciated, hematite-stained gneiss.

11) Narrow quartz vein strikes N 65° W and dips 53° SW.

12) Minor quartz in fault zone that strikes N 65° E and dips 53° NW in gneiss.

13) Mohave Mine - Not much to see here. Main dump has much siliceous granite (almost a pegmatite). Looks like shaft sunk on pegmatitic granite body cutting gneiss.

14) Gold Bug Mine - Not much outcrop here. Shafts appear to be on two parallel structures which may be contacts of high-angle mafic dike or dikes. cutting gneiss. I got strikes of N 35° E and N 55° E. Structures extend about 300 feet on surface.

15) Minor quartz lens in unaltered gneiss.

16) Porter Mine - Relationships not well exposed. Probably along a fault trending N 40° W and dipping 30° NE in gneiss.

My general impression of the Gold Bug District is that only the Van Deemen Mine might warrant closer examination if my samples H-18 and H-19 show significant gold and silver values.

Mocking Bird District

17) Mocking Bird Mine - Numerous shallow pits in lamprophyre. Apparently a flat-lying body with some brecciation and shearing. Would make a good drilling and mining target. Some Cu oxides. Worth mapping and sampling if my one sample shows gold values.

SAMPLE	Au (ppm)	Ag (ppm)
H-20 - Sheared lamprophyre with silicification and some Cu oxides.	8.3	12

18) Dandy Mine- This might be Schrader's "Hall" Mine. Narrow shear in granite gneiss strikes N 50° E, dips 50° NW. One drill hole noted.
19) Great West Mine - Narrow, argillized fault and fracture zone in Precambrian granite structure strikes about N 85° E and is about vertical. Younger dike appears to trend northerly across mine area.
20) Pocahontas (?) Mine - Not much to see here. Old shaft is now utilized as a well. Country rock is granite gneiss.
21) Kemple Camp - Not examined. Small exploration or development project in progress January, 1981. Camp is occupied.
22) Relatively flat-lying mafic dike cuts gneiss adjacent to porphyritic granite dike.

SAMPLE	Au (ppm)	Ag (ppm)
H-21 - Brecciated, altered and copper-stained gneiss in 4-ft. vertical cut below mafic dike.	0.9	1

Pilgrim District

The district has apparently been completely taken up by a single operator. I saw evidence of at least 278 claims (Golden Door Extension) staked by D. K. Martin, 4728 West 21st Avenue, Phoenix, Arizona 85015. There is a large camp (unoccupied when I visited) with numerous drill roads and drill holes. I visited briefly at the Dixie Queen Mine, and it appears to offer some potential for a disseminated type of precious metal deposit. A white, Tertiary rhyolitic body intrudes a latite along a southeasterly trend with a dip to the northeast. In the mine area the workings seem to follow the contact where veinlets of quartz and calcite also occur. The zone has been followed at least 600 feet and has obviously been mapped and sampled recently. This looks like a good project where we are simply too late.

Property file: Mohave Co., AZ = Gen. Recon by NLA

HUNTER MINING LABORATORY, INC.

994 GLENDALE AVENUE • SPARKS, NEVADA 89431 • TELEPHONE: (702) 358-6227

REPORT OF ANALYSIS

Submitted by:

DEPCO, INC.
390 Freeport Blvd., Suite #12
Sparks, Nevada 89431

Mr. N. L. Archbold

Date: February 2, 1981

Laboratory Number: 9004

Analytical Method: AA

Your Order Number:

Report on: 20 samples

Sample Mark:	Gold ppm	Silver ppm	Sample Mark:	Gold ppm	Silver ppm
H-1	1.5	18	H-11	0.2	-1
2 Eldorado	0.1	2	12	0.1	-1
3 Pass	2.3	20	13	1.9	1
4 Dist	1.1	5	14	-0.1	-1
5	1.4	10	15	-0.1	-1
6	-0.1	-1	16	1.1	2
7	-0.1	-1	17	-0.1	-1
8	-0.1	-1	18	6.0	9
9	0.1	-1	19	0.7	3
H-10	1.7	1	H-20	8.3	12

HUNTER MINING LABORATORY, INC.

Gary M. Fechko

Gary M. Fechko

ppm = parts per million. **oz/ton** = troy ounces per ton of 2000 pounds avoirdupois. **percent** = parts per hundred. **fineness** = parts per thousand.
ppb = 0.001 ppm. Read — as "less than." 1 oz/ton = 34.286 ppm. 1 ppm = 0.0001% = 0.029167 oz/ton. 1.0% = 20 pounds/ton.

Ore deposits of the Wallapai District, Arizona
(Article from volume 44, no. 8 of Economic
Geology) by Blakemore E. Thomas

MULTIDISCIPLINARY MINERAL RESOURCE STUDIES IN THE INDIAN PASS AND PICACHO PEAK BUREAU OF LAND MANAGEMENT WILDERNESS STUDY AREAS, IMPERIAL COUNTY, CALIFORNIA | № 71093

SMITH, D. B., BERGER, B. R., and RAINES, G. L., U.S. Geological Survey, Denver, CO 80225; TOSDAL, R. M., GRISCOM, A., and HELFERTY, M. G., U.S. Geological Survey, Menlo Park, CA 94025; McMAHON, A., U.S. Bureau of Mines, Spokane, WA 99202

Geologic, geochemical, and geophysical studies were used to evaluate the mineral resource potential of the Indian Pass and Picacho Peak study areas in southeasternmost California. These study areas comprise 57 square miles within the California Desert Conservation Area. The work included geologic mapping; reconnaissance geochemical surveys using minus-80-mesh stream sediments, heavy-mineral concentrates from stream sediments, and rocks as sample media; and aeromagnetic and gravity surveys. LANDSAT images were used to map the generalized distribution of limonitic materials as a guide to hydrothermal alteration and rock samples were collected for analysis from areas of observed alteration.

Two regions of interest within the study areas were delineated by multiple element anomalies in heavy-mineral concentrates. One region is characterized by anomalous W, Bi, Cu, Pb, and Mo. The other region contains anomalous As, Sb, Ba, B, and Sr. Another region of interest in terms of resource assessment is that underlain by a relatively narrow E-W trending belt of gneiss of Precambrian(?) and Mesozoic age which composes the upper plate of the Chocolate Mountains Thrust. This gneiss is similar to the host rock at the Picacho Mine and perhaps to the gneiss in the gold mining areas in the Cargo Muchacho Mountains and at the Mesquite deposit, which are all within ten miles of the study areas. Rock samples from these mining areas are compared geochemically with similar rock types from the study areas.

GEOCHEMISTRY OF POST-15 M.Y. OLD VOLCANIC AND PLUTONIC ROCKS IN THE RIVER MOUNTAINS-HOOVER DAM AREA OF SOUTHERN NEVADA AND NORTHWESTERN ARIZONA | № 60165

SMITH, Eugene I., and MILLS, James G. Jr., Department of Geoscience, University of Nevada, Las Vegas, NV 89154.

Late-Miocene (12-15 m.y.) volcanism in the River Mountains-Hoover Dam area resulted in the eruption of subalkalic/alkalic andesite and dacite from stratovolcano complexes, and alkali basalt from small shields. Compositionally variable plutons (diorite to granite) were emplaced during the same episode of activity. Pliocene activity (4 to 6 m.y.) produced alkalic basalt flows from north-northwest trending dikes (Fortification Hill basalts). Magma types were generated by partial melting of tonalite to quartz monzonite crust (suites 1, 2 and 4), or mantle (3 and 5). Chemical differences between magma types are due to variations in source chemistry and/or to degree of melting. Fractional crystallization is responsible for compositional variation within each type. The magma types are: 1) Upper Black Canyon suite containing three groups a) Boulder City pluton b) Wilson Ridge pluton c) Hoover Dam volcanics. The groups are related by having a similar parent composition (58% SiO_2, Sr=500-800 ppm, total REE=300 ppm, Ce/Yb=15). Subsequent fractional crystallization (biotite-feldspar dominated for Boulder City; hornblende-feldspar for the other groups) accounts for the chemical variability within each group. 2) River Mountains suite-andesite and dacite flows and domes and a quartz monzonite stock (Sr<200 ppm and total REE=<300 ppm). 3) Mafic group A-basalt dikes of Mt. Davis age (11-15 m.y.) that cut the Wilson Ridge pluton, and dikes and flows of basalt and andesite in the northern River Mountains (La=400-500/chondrite, Ce/Yb=37 and Eu/Eu*=.65). 4) Mafic group B includes two andesite units (56% SiO_2) in the Hoover Dam area that are depleted in LREE (La=200/chondrite) compared to mafic group A. 5) Mafic group C-the Fortification Hill basalts (Ce/Yb=5 and total REE=95 ppm).

DEPOSITS OF COARSE NON-MARINE VOLCANICLASTIC SEDIMENT: PROBLEMS OF TERMINOLOGY AND DEPOSITIONAL PROCESS | № 73623

SMITH, Gary A., Dept. of Geology, Oregon St. U., Corvallis, OR 97331

Studies of modern and ancient alluvium emphasize deposition by debris flow or normal streamflow processes without attention to deposition over a range of sediment/water ratio for which these processes are end members. Because explosive volcanism leads to rapid mobilization of large volumes of sediment on a scale rarely observed in non-volcanic settings, deposits intermediate to the end members, attributed to hyperconcentrated flood flow (HFF), are common in Cenozoic volcaniclastics in the Pacific Northwest, including modern sedimentation near Mt. St. Helens. Debris flow deposits have characteristics of mass emplacement: matrix support, unstratified, usually ungraded or inverse-to normal graded. HFF deposits are distinct from debris flow deposits by characteristic clast-support, distribution normal grading, and horizontal stratification. HFF deposits are distinct from normal streamflow deposits by lack of cross-bedding in sandy deposits and, in coarser deposits, very poor sorting, poorly developed imbrication, and abundance of clasts with a-axis parallel to flow direction. HFF deposits are important components of the 7 volcaniclastic sequences studied and their lateral and vertical relationship with debris flow deposits suggests that in many cases they result from downstream dilution of channelized debris flows. General lack of consideration of HFF deposits in previous literature reflects:1) that such deposits are best represented, as compared to other settings (e.g. arid alluvial fans), in arc-adjacent basins where sedimentological study is generally lacking; 2) that such deposits have been inappropriately ascribed to the end member processes; and 3) the ambiguous use of the term lahar, whose further usage is discouraged. Successful evaluation of volcaniclastic sequences, for basin analysis or volcanic hazard studies, requires recognizing that existing fluvial facies models do not adequately consider the influence of volcanism -induced sediment loads on fluvial systems.

FOSSIL AND K-AR AGE CONSTRAINTS ON UPPER MIDDLE MIOCENE CONGLOMERATE, SW ISLA TIBURÓN, GULF OF CALIFORNIA | № 69885

SMITH, J.T., SMITH, J.G., U.S.Geological Survey 345 Middlefield Rd., Menlo Park, CA 94025; INGLE, J.C., Dept. Geol., Stanford Univ., Stanford, CA 94305; GASTIL, R.G., Dept. Geol. Sci., San Diego State Univ., San Diego, CA 92182; BOEHM, M.C., Union Oil Co. of California, PO Box 6176, Ventura, CA 93006; ROLDÁN Q., J., Instituto de Geología, UNAM, AP 1039, Hermosillo, Son., Mexico; and CASEY, R.E., Dept. Geol., Rice Univ., PO Box 1892, Houston, TX 77251.

Marine fossils indicate that seawater entered the Gulf of California at least 12 m.y. ago, or 7 m.y. before spreading began at the mouth of the gulf. Interstratified marine and nonmarine sedimentary and volcaniclastic rocks crop out in arroyos draining into Bahía Vaporeta, 3-4 km NE. of Punta Willard. More than 2 km of alternating fluvial and nearshore to shelf deposits dip 20°-30° W. and N.; angular to rounded pebble and cobble conglomerate and sandy siltstone grade upward into nonmarine andesitic volcaniclastic beds. The age of the upper part of the unnamed marine unit (T3m of Gastil and Krummenacher, GSA MC-16) is constrained by two K-Ar ages: 12.9±0.4 m.y. on a clast from an interbedded monolithologic debris flow (J. G. Smith sample 83BSJ260, from lat. 28°53.7'N., long. 112°30.6'W.), and an age of 11.2±1.3 m.y. on an unconformably overlying ash-flow tuff (Gastil and Krummenacher, 1977, GSA Bull. v. 88, sample S2B-27). Foraminifers from 20 m downsection from the dated flow include tropical to subtropical species of Amphistegina, Cancris, Hanzawaia, and Globigernoides obliqua. The marine conglomerate, possibly a flash-flood deposit, contains "Aequipecten" muscosus (Wood) and Nodipecten nodosus (Linnaeus) that live today from the Caribbean to Brazil, as well as giant oysters, pectens, Turritella sp., barnacles, and echinoids. Megafossils suggest that this marine conglomerate is penecontemporaneous with the lower part of the Boleo Formation near Santa Rosalía. Subduction off western Baja California ceased about the time of deposition, tilting, and erosion on Isla Tiburón about 12 m.y. ago, at least 5 m.y. before the East Pacific Rise began rifting Baja California from mainland Mexico.

SEDIMENT ROUTING IN A SMALL WATERSHED IN THE BLAST ZONE AT MOUNT ST. HELENS, WASHINGTON | № 73901

SMITH, Richard D., Geology Dept., Oregon State Univ., Corvallis, OR, currently at Redwood National Park, 791 8th St., Arcata, CA 95521

A descriptive model of the routing of sediment delivered to the study area by the 1980 eruptions of Mount St. Helens was developed. On hillslopes this sediment was distributed among three major storage compartments: 1) the tephra profile, 2) primary storage, and 3) secondary storage. The most important sites of hillslope sediment storage were colluvial wedges and sites upslope of logs or other organic debris. Hillslope erosion processes, including sliding off slopes steeper than 0.70, rill erosion and inter-rill erosion, redistributed sediment on the hillslopes and delivered sediment to the channel system.

Sediment from the 1980 eruptions was delivered to the channel system by direct deposition or by hillslope erosion processes. Much of this sediment was then transported by fluvial erosion and either redeposited in the channel or exported from the watershed. Important sites of sediment storage in channels included alluvial fans, sites related to logs, channel bed storage, and alluvial terraces.

Twelve percent (49,000 t/km^2) of the sediment delivered to the study area (400,000 t/km^2) was delivered to the channel system in the first post-eruption year. Six percent (24,000 t/km^2) remained in storage in the channel system and six percent (25,000 t/km^2) was exported from the watershed.

DISCRIMINATION OF IDAHO BATHOLITH PLUTONS BY STRUCTURE AND AGE | № 71755

SNEE, L. W., LUND, Karen, HOOVER, A. L., U.S. Geological Survey and Department of Geology, Oregon State University, Corvallis, OR 97331

In west-central Idaho, Mesozoic plutons representing three magmatic events can be discriminated by studying structural relations and by $^{40}Ar/^{39}Ar$ dating. Tonalite and quartz diorite plutons (Group 1) were emplaced in metamorphic basement before 225 Ma and into the Riggins Group-Seven Devils arc terrane at ~150 Ma. Low grade metamorphism associated with suturing of this allochthonous terrane to the continent at ~118 Ma caused a loss of potassium in many of these plutons. The oldest plutons of the Idaho batholith are quartz diorite, tonalite, and granodiorite with hornblende $^{40}Ar/^{39}Ar$ plateau ages ranging from 93 Ma to 79 Ma (Group 2). Early plutons of this group intruded the suture zone during final movement along the zone and are foliated. Unfoliated, apparently cogenetic, plutons of this group cross-cut foliated plutons and appear to be post-deformational. Many of the foliated plutons of Group 2 were emplaced at depths >25 km, and cooling rates of ~90°C/Ma indicate rapid uplift following emplacement. Cooling curves and muscovite $^{40}Ar/^{39}Ar$ plateau ages indicate rapid uplift, cooling, and erosion of Group 2 plutons and hosts preceded the emplacement of massive, voluminous, muscovite-biotite granite plutons between 75 Ma and 70 Ma (Group 3). Plutons of all three groups have been called Idaho batholith, but the plutons of Group 1 were formed within an allochthonous terrane before accretion and are thus unrelated to the batholith. Plutons of Groups 2 and 3 formed after accretion and are thus true plutons of the Idaho batholith; the distinct compositions and large sizes of the plutons in these groups, however, preclude a direct genetic relationship between them.

1985 GSA

Sugarloaf Alunite
- EMJ v 136 #3
1938

Moon Mtns - AZ Placers, N York City, Bull 451, W dep, Bull 871, USGS Bull. 1355

ABMG files - 47, 49, 87, 282, 320, 436, 594, 604, 661

USGS Bull 620-C - 667, AZ Bull 192 697, 772, 779, 1102, 1103, 1237, 1286,
1389, 1391, 1394

USGS Bull 352

~~Alunite of AZ~~
~~USBM RI 3561~~

Bull 961
Artill Mtn.
older - mentions
breccia zones
along thrusts

AZ Bull 166 Placers

US - AZ Bull 122

USGS Bull 936R

Rawhide - 356 (Cord Met. Corp?), 430, 764, 765, 766, 961, 962,
1066, 1070, 1157, 1158, 1159, 1173,

Core Complexes

Rawhide Mtns PHD. Shackleford U.S.C.

Cataclastic Rx, 1976 - Rawhide Mtns MS Thesis SDSU

1978
GSA Bull.
v. 89, no. 6
p. 921

p. 32 Bull 451
just SE of Castaneda Well
small hill (~200' high) of rhyolite
brecc. plug - Castan... well
is ~6 mi due W of McCracken Mine

USGS Bull 961

Geology Journal

Cleopatra - 356, 430, 766, 961, 962, 1066, 1070, 1118

ODUS Volumes

W dep.

Core complex - GSA Mem 156

MS Thesis SDSU cenozoic Geology

Artillery Pk - 22, 45, 47, 331, 356, 461, 501, 574, 604, 666,
667, 668, 697, (RI 5292) 753, 764, 765, 779, 832, 874
932, 933, 959, 960-964, 984, 1066, 1070, 1113, 1117
1135, 1136, 1173, (1265, 1374, 1378, 1393, 1394, 1395

Bull.

AGS Digest V. 12

Min. & Sci. Press
v. 113, no. 21
1916 p 733 -

AIME Bull
v. 119 p. 1535
v. 123 p 379
v. 124 p 456

AIME Trans.
v. 56 pp. 195

~~AZ Bur~~

PE Carrizo - near Parker Az Bull 137 p. 127; US Bull 451, p. 76
Az Bull 192, p. 122, 123, 142

Cibola - Trigo Mtns, Az Bull 134 p. 72-73; Az Bull 192, p. 179-181

Epi. Sheep Tanks - Az Bull 137, p. 144; Az Bull 134, p. 138
(part w/ dravon) Az Bull 192, p. 174

Det. Harquahala - Alaska Mine Az Bull 137, p. 133

Cemetery Ridge - Eagle Tail, Az Bull 134 p. 142-143, Az Bull 192 p. 145-146

PE Mohawk - Ruby Mine - Az Bull 134, p. 153

Det?- Planet - US Bull 451 - p. 51, 56, 58; Az Bull 192, p. 71
-PE? (Swansea) Az Bull 192, p. 172

Epi. Moon Mtns, Valensula Prop. - US Bull 451, p. 80

intru? Plomosa Mtns, - US Bull 451, p. 87, 93, 8; Az Bull 192 p 66, p. 165, 168-169, 170
w/ CO?

PE Granite Wash (Ellsworth) - US Bull 451, p. 98, 102, Az Bull 192 - p. 38
Az Bull 192, p. 146, 147, 148, 149

Harquahala - US Bull 451, p. 112, 113, Az Bull 192 - p. 151-154

Cunningham Pass - US Bull 451, p. 119, AZ Bull 192 - p. 31
AZ Bull 192, p. 143, 144, 145

Det.? Midway Dist - US Bull 451, p. 122
(NE. of Bouse)

Pt?, Chloride Dist - selected properties - US Bull 397 - p. 61, 62, 75-76,
intr Mineral Park 78, 79, 88, 89

intr? Cerbat - US Bull 397 - p. 92, 106

Det Gold Basin - US Bull 397, - p. 124, 125, 126, 127

Det. White Hills - US Bull 397 - p. 133

~~Oatman Gold Rd.~~

EPW- Mocking Bird Dist - US Bull 397, p. 216
Det. (N. of Kingman)

Pt Laguna (Las Flores) - AZ Bull 134, p. 214-216, AZ Bull 192, p. 50, 157,

Det Artillery Dist. (Rawhide Mtns. Area) - USGS Bull 936-R, 961
AZ Bull 192, p. 114-115

Dome Dist (near Yuma) - AZ Bull 192, p. 145

La Cholla Dist. (SW of Quartzsite) - AZ Bull 192, p. 156, 157

La Paz (weaver) - Middle Camp - Az Bull ~~128~~ 192, p. 158, 159, 161,
~~Az~~ ~~B1~~ US Bull 451, p. 85-86

Yuma Dist - Az Bull ~~131~~ 192, p. 81

#13 Sheba Mine, #16 True Blue (Babbitt)
- irregular qtz - siderite veins w/ Au along NW trend shears, schistosity w/ intrusives

Gila Bend Mtns. - (near Gila Bend)
- 3 prospects in PE w/ qtz, alteration

Harquahala
#1, 9, 13 - irreg. qtz veins along shears trend NW

La Cholla - SW of Quartzsite
#4 - Yum Yum Mine - qtz veinlets along bedding planes in ~~schist~~ Meso. schist?

Laguna - N. of Yuma
#2 - Las Flores Group - small veinlets along shear zone

La Paz - W side of Quartzsite
- #5 Goodman Prosp - qtz vein in NW trend shear

Middle Camp - West of Quartzsite
#1 Julian, #3 Marquette

Plomosa
#14 Dutchman, #19 Humdinger, #20, Iron Cl near Bouse
#24 Little Butte, #27 Old Maid
- various settings

Santa Maria (Planet, Swansea)
#1 Angels Mine and others - breccia zones w/ hematite

Trigo (N. of Silver - Eureka Dist)
#10 - Grand Central Mine - fault zone w/ dike

Yuma
#1 - stringers, veins w/ Au

Yuma City Rept. by Colburn for Perry

Sheeptanks area - mentions Allison Mine E of
Sheeptanks Mine - see AZ Dept. Min Res files

Cemetery Ridge - W. end Gila Bend Mts.
AZ Dept. Min Res. files - Davis Group

Areas to check:

Peripheral to Oatman Dist. - Boundary Cone area, ~~etc~~, Secret Pass, etc, get USGS Bull 743, AZ Bull 131 article by Schrader - stress association w/ late intrusives. look at Moss Mine area (NW of Oatman), p. 46 - Bull 131 - "Along Silver Creek
also p.62 ⇒ altered brecc. Moss porph. p.48 - rhyo. dikes - plugs related to Times porph.
p. 57 110 ⇒ Bull 137 - Gold Dust vein, p. 89 Bull 131., placers along Silver Creek - no real veins
Gold Springs Dist, Utah - p. 96 Bull 131
~~Gold~~ Leland Mine, p. 111; Sunnyside Mine, p. 112
p. 113 - Moss Mine; p. 116 Katherine Mine, p. 118, Pyramid Mine; p. 124 Black Dyke

---

p. 98 - Bull 137 - Goddis - Perry vein

EMJ v. 123, p. 716-720, 1927 - Katherine Mine

AZ. Gold Mines

Bull 137 p. 127 - Cunego Dist. - Rio Vista, Sue and Capilano Mines
Bull 137 - p. 133 - Alaskan Mine - is detachment?? seems to have all right ingredients

Bull 137 p. 144 - Sheep Tanks OUT
Bull 137, p. 151 - Wellton Hills - La Posa Dist OUT

AZ Bull. S. Yuma Cty

Bull 134 - p. 72-73 - Cibola Region - ~~Hardt~~ Trigo Mtns. Boardway - Jupiter Mines
Bull 134 - Castle Dome Mtns. - OUT Flat dips
most veins, etc. near diorite or qtz porph. dikes
Bull 134 - p. 135 - Sheep Tanks Mine - silicified fault in volc. breccia hosts ore - could be related to intrusive diorite porph. - lots of brecciation - ore zone dips shallowly N. - could be hydrothermal breccias like Stedman?? - don't know enough,
OUT

Bull 134, p. 142-143 - lots of dikes, breccia zones
-Cemetery Ridge - Eagle Tail Dist. - Bull 192
Bull 134 p. 153 - Ruby prospect - Mohawk Mtns.
Bull 134 p. 172 - Wellton Hills (La Posa) ↳ mentions
OUT → brecciated zone w/ dikes and alteration, Au in wallrock
Bull 134 - p. 185 - area around Red Top Pk - Gila Mtns.
2 mica granite - related to gold veins, Fortuna Mine.
OUT
-big discussion of area

---

look at Breccia rx in Antelll Pk Area.

U.S.G.S. N. Yuma Otis Bancroft.

Bull 451 - p. 51 - qtzite w/ Au near Planet Mine.
451 - p. 56, 58 fig. 7 - altered lime shale, description of workings, etc, at the Mineral Hill area near Planet
Bull 451 (Cienega Dist) - p. 76 - Billy Mack prop. - dark chlorite - mica schists
451. - p. 80 - Valensuella prop - low dipping flt. zone w/ minerals, low Au
451 - p. 83-84 - Cinnabar prospects in S. Dome Rock Mtns. -
OUT have Au-Ag with the - checkout - in schists w/ alteration, w/ tourmaline, magnetite.
p. 87 - New York - Plomosa placers - note small veins nearby - SW flank Plomosa Mtns. - could be detachment?
p. 93 - Little Butte & Vicinity - - Little Butte itself - altered granite w/ qtz veins, PE limestone w/ Cu, Au, ?placement, sounds interesting.
p. 98 - Mentions numerous qtz veins along joints - bedding planes in schists, etc in general W. Harcuvar Mtns - Bullard Wash area are PE!?
p. 98 - Arizona Northern - PE?! open pit target - lots of small veins in qtz mica schist - amphibolite
deposits related to secondary enrichment of Au-py p. 102 - Desert Prospect - similar to Ariz. Northern
Report by Stan Keith! probably others along trend (p. 112 - Socorro Mirage - lots of PY in surrounding rocks, flat dipping veins in two qtz mica schists (exhalite zones??)
p. 113 - San Marcos - N side of Harquahala Mtns. - shallow N dip vein, altered rx.
p. 119 - "Many ledges of siliceous limonite" - Cunningham Pass Area.

p. 122 Mammoth Deposit, Oatman Vicinity NE of Bonze
- possible detachment surface w/ Cu, F, Ba

Bull 397

Chloride Dist
- p. 61 - Badger Mine, "Big Vein" - $12/ton Au, prominent vein, open cuts
- p. 62 "Pay Roll" Mine, vein to 100 feet thick, "large body of low grade ore"
- p. 75-76 Pinkham - Midnight Mine - large veins - good grade
- p. 78 - Keystone - numerous veins - stringers - large dumps of low grade - also Tuckahoe
- p. 79 - Tintic - flat vein w/ good gold

Mineral Park
- p. 88 - Ark - San Antonio - "Cross Vein" - sheer zone w/ low grade Au
- p. 89 - Annie Prospect - mineral zone w/ dikes and gold, Ag, Cu

Cerbat
- p. 92 - "great white dike" - appears related to mineraliz.
- p. 106 - Blanket vein - flat dipping vein - w/ gold, stripped off, no Pb, Zn, Cu/Ag

Mines N. of Cerbat wash mostly Au, those to S mostly Ag-Pb. Many veins associated w/ later dikes

Gold Basin
- p. 124 - Golden Rule Mine - Blanket vein - dips 25°SE 3-5' thick.
- p. 125 - Cyclopic - sounds like detachment - has red clay layer under all qtz veins + some in breccia
- p. 126 - Gold Belt Mine - has 2 blanket (flat-lying) veins
- p. 128 - Senator Mine - described like Cyclopic

Check out area in general

White Hills
- p. 133 - flat veins at Prince Albert & Daisy Mine

Bull 397 - p 157 - younger rhyo. dikes carry gold

Gold Road Dist

"12-50' wide, 600' S. of mine - $5-6 ore in stringers of qtz-calc. in dike.
vein follows dike
- hard walls suggest better ore

p. 168 - Pasadena Mine - vein 10-140 feet thick - better grade w/ more width

p. 169 - Mossback Mine - rhyolite dikes - partly mineralized to $2-3/Ton, w/ veins, stringers in dike at surface

p. 175 Meals ledge - wide, low grade vein, ave ~ 40'

p. 177 Miller mine - altered micropegmatite assoc. w/ vein, vein replaces it, and grades into vein.

p. 179 - Gaddis - Perry Angle - mineraliz on both sides of large micropegmatite dike w/ alteration, silicification - Gaddis - Perry on ~~E~~ S side, Angle on ~~W~~ N side - dike trends E-W - parallel to Hardy vein. - "deposits connected w/ micropegmatite" - p. 180 - notes change of micropeg. into qtz vein, both w/ gold.

Vernon Dist

{ ~~p. 186~~ p. 188 - German - American Mine - 35th parallel draft - Treadwell Shaft area of 70' wide vein x 600' long

Boundary Cone Dist

{ p. 203 - deposits at contact w/ Boundary Cone rhyolite and dikes, has qtz veins + altered rhyo w/ Au

Union Pass Dist. -

lots of flat dipp. veins

p. 206 - Union Pass Area - rhyolite dikes assoc. w/ veins, Catherine Mine, Pyramid Mine) Typo

p. 207 - in east. part, veins all at contact w/ rhyolite dikes

p. 210 Expense Mine - notes ore in altered, vuggy silicified rhyolite -

p. 211 "Union Pass Mine - near rhyo, large vein, w/ breccia, etc."

Mocking Bird Dist p. 216 - flat lying veins in volcanics along contacts

check refs in AIME paper by Schrader, 1916

p. 219 - Gold Road Mine - rhyolite dike w/ gold - $8/Ton - 80' wide 600' S. of mine, w/ stringers

p. 226 Ivanhoe Mine - footwall is 75' qtz porph. dike partly mineralized

p. 227 Black Range Mine - Boundary Cone Dist - replacement of wall rock for 60' or more

p. 226 Secret Pass Dist. - Ransome mentions - replacement ore in wall rocks of dike.

p. 233 - Williams - Eclipse rhyolite dike - Secret Pass - has gold mineral. in footwall of dike - Nancy Lee Mine, Eclipse Mine, Wilhelm Mine - dike cuts P€ and younger chlorite andesite

p. 234 - rhyolite dike at Murdock mine - S of Boundary Cone - gold mineral. in and along footwall of dike - grades into Nellie Vein? - dike intrudes vein? p. 235 silicified flows w/ Au -

p. 236 - pyritic wallrock w/ Au - Orphan claims, Secret Pass Dist - along fault - W. boundary Secret Pass Dist. - also another rhyolite dike has mineralized P€ granite - Secret Pass Dist.

	Schrader	Ransome	Lausen	Thorsen
↑ Younger ~~Older~~ ↓ ~~Younger~~			~~Murdock Breccia~~	
		Olivine basalt	Same	
		Cottonwood rhyolite		
		Sitgreaves tuff	Same	
		Meadow Crk trachyte	Antelope Rhyolite	
		Flag Spring ~~trachyte~~ trachyte		
	"undifferentiated volc. rx.-rhyolite series-younger andesite"	Gold Road latite	Same	
	"green chloritic andes."	Oatman Andesite (local intru.)	Same	
	"phonolite" & dark andesite	Esperanza trachyte	Same	
	basal andesite-older andesite-grey andesite	Alcyone trachyte (local intru)	Same	
		Breccia w/ PE blks	Murdock Brecc.	
	PE granite	PE granite		

Intru. Rx	Micropegmatite ↓ Younger?	Moss porphyry - comp. of Gold Rd Latite - younger than Oatman Andes.	10 m.y. K-Ar
		Times porphyry - comp. of Cottonwood Rhyo	22 m.y. K-Ar
		Rhyolite Plugs - Boundary Cone - Elephant's Tooth	Youngest
		Mineralization	

USGS

Bull 743 - Oatman - Ransome

p. 48 - Moss Mine - 220' bull vein - 90' wide - $3-4/ton w/ Au (.15-.20 oz/T)

AZ Bull 192 - Yuma Cty - Az

S. New Water Dists. off limits - Fortuna, La Posa, E. Trigo Mtns, Laguna ?, Frisco, S. La Cholla Castle Dome, Blacktop, Neversweat, Tank Mtns, Kofa, Harrisburg, Alamo Springs, Fools Folly S. Mohawk Muggins E. Silver-Eureka

p. 31 - Cunningham Pass Dist - "hematite ledges w/ gold"

p. 38 - Ellsworth - sounds good

p. 50 - Laguna dist. - Las Flores area - Au in irreg. qtz veins in pt

p. 60 - check areas in Muggins Mtns. for land status

p. 66 - Planosa Dist - N. part has Au

p. 71 - Santa Maria Dist (Planet - Swansea)

Alamo Dist (SE part of Artillery Springs Mn area)

#1 - Montana - Arizona Mine, #8 Mystery Mill group

- Cu, Au, Ag - related to thrust(?) faults, alteration.

Cienega Dist (near Parker)

#1, 2, 3, 4, 5, 6, 7, 8, 16 - mostly Cu, Au, Ag assoc. w/ hematite in breccia zones, thrust faults, alteration

Cunningham Pass (NE of Salome - Harcuvar Mtns.)

#1, 2, 3, 4, 5, 6, 7, 10 - mostly Au, Cu assoc w/ hematite, qtz in veins along NW trending shears

Dome Dist - (near Yuma)

#3 - irregular gold - qtz veins

Ellsworth (Granite Wash Mtns)

#5 - Desert Mine, #7 Glory Hole (Arizona Northern),

WESTERN ARIZONA EXPLORATION PROJECT

Definition of Mineralized Areas and Target Types for La Paz, Mohave and Yuma Counties

Favorable Criteria for Exploration

Within the La Paz - Mohave - Yuma County area criteria used to define mineralized areas for exploration and evaluation are as follows. Peripheral areas to those outlined should also be included in this regional tabulation, particularly if exploration is favorable at the specific areas or properties.

1. Known gold-silver mineralization or past primary gold-silver production from both hardrock and placers.

2. Structural preparation including detachment faults, thrust faults, high angle normal and reverse faults, caldera ring fracture zones, breccia pipes, intrusive breccias, etc., the more, the better.

3. Host rock types including PreCambrian differentiated volcanic sequence (greenstone to sericite schist), hot spring deposits, hydrothermal breccias, alkolic (syenitic) intrusives, porous sedimentary-volcanic units.

4. Associated favorable rock types - rhyolite intrusives (domes, plugs, dikes), dike swarms, alkalic intrusives; intrusives are better if contemporoneous with structured preparation.

5. Alteration of most kinds in any kind of rock (argillization, silicification, propylitization, hematitization, Na- or K-metasomatism).

6. Associated mineralization - quartz veining, stockwork zones and other prospects with associated favorable trace elements - mercury, antimony, arsenic, tungsten, barite, etc.

7. A perceived lack of post or current exploration activity primarily for gold-silver.

8. A favorable land position is obtainable; few competitor claims, ground open for location, no withdrawals, etc.

Within the La Paz - Mohave - Yuma County area the recognition of the above criteria is severely hampered by a general lack of suitable detailed geologic maps. In addition, while not an exploration criteria per se, the aggressive pursuit of joint venture opportunities will be conducted and encouraged.

Target Types

Target types within areas categorized as mineralized or favorable for exploration have been broadly defined as detachment-related, other structural preparation, Precambrian, epithermal and intrusive. Favorability criteria used to determine which target type may be associated with a given mineralized area are defined below.

Detachment - detachment or other low angle extensional structures in an area with numerous high angle structures. Post-detachment intrusives and regional alteration.

Other Structural Zones - Areas of complex structural preparation with numerous intersecting faults showing repeated movement. Wide altered breccia zones and contemperoneous or younger intrusives.

Precambrian - Differentiated, cyclical volcanic sequences ranging from basolt-andesite through rhyolite. Contemporaneous sedimentation and intrusive eactivity.

Epithermal - Numerous high angle and/or low angle structures within a complex volcanic center. Contemperoneous extrusion, intrusion and sedimentation. Large breccia zones, zojned alteration and silicification.

Intrusive - Alkalic to calc-alkaline intrusives within areas of complex faulting, with developed regional alteration including metamorphism and stockwork disseminated zones within and peripheral to intrusive, and regional metal zoning.

Discussion

As can be seen on the accompanying map of mineralized areas coded for target types the main areas suitable for exploration are primarily of two types, detachment and epithermal. In some cases these two types are perhaps superimposed. While datachment faults are being recognized through much of western Arizona those associated with mineralization seen to cluster along an east-west trend aside the Bill Williams River. This grouping seems to coincide with a number of strong northwest-southeast trending high-angle structures with coincident dike swarms and aligned intrusives.

Many epithermal deposits are strung out along the Colorado River and, at least in Mohave County, seem to be associated with similar mineralization in southern Clark County, Nevada and adjacent California. In detail, most mineralized structures trend northwest-southeast. A particularly favorable place to explore may be within and peripheral to known epithermal mineralized areas looking for as yet unrecognized detachment older faults which may host minieralization.

A prioritized list of mineralized districts within La Paz, Mohave and Yuma Counties follows and it is recommended that these areas be evaluated first.

Monave	Cleopatra	Detachment
	Chemihuevis	Epithermal Detachment
	Cyclopic	Detachment
	Greenwood	Precambrian
	Oatman	Epithermal
	Pilgrim	Epithermal
	Topock	Epithermal
	Union Pass	Epithermal Detachment
	Virginia	Detachment
La Paz	Alamo	Detachment
	Cienega	Detachment
	Cunnington Pass	Other structure
	Ellsworth	Precambrian
	Grand Central	Precambrian
	Harquahala	Detachment
	Moon Mtns	Detachment Epithermal
	N. Plamosa	Intrusive
	Swansea	Detachment
Yuma	Dome	Precambrian
	Sheep Tanks	Epithermal

1&U

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
LA PAZ COUNTY			
Alamo, MD (sa Artillery, MD)	F 3	Detachment	Cu, Au, Pb, As
Cienega, MD (sa Mammon, Pride)	F 2	Detachment	Cu, Au, Ag
Clara (Santa Maria, MD)	F 3	Detachment	Cu, Ag, Au
Cunningham Pass, MD (sa Harcuvar)	F 3	Other Structure	Cu, Au, Ag, Pb
Eagle Tail (sa Cemetary Ridge)	G 3	Epithermal	Cu, Au, Ag Mn, Ba

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
Vein-type deposits in altered PreC rocks in and near low-angle detachment faults. Associated(?) intrusive rocks.	Montana-Arizona gp; Mystery Mill gp	Az Bull 192, p.17-19, p.114-115; USGS Bull 461, Shackleford thesis, USC
Replacement bodies in Paleozoic(?) ls and as pods, lenses within and near silicified breccia (detachment) zone within PreC rocks.	Arizona McGinnis, Arizona Pride, Billy Mack, Capilano, Carnation, Eagle Nest, Golden Ray, Lion Hill	Az Bull 187, p.127; Az Bull 192, p.26-29, p.122,123,142; USGS Bull 451, p.73-77; And-Ham Vol. Al-Hashimi, Fernandez, Zamorano theses, U of Mo-Rolla
Pods and lenses of CuOx with some gold at brecciated detachment contact of Tertiary seds and PreC.	Clara, Mineral Hill	Az Bull 192, p.67-72, p.173; Az OF 80-2, USGS Bull 451, p. 40,51, 59,60; And-Ham Vol.
"Poddy" quartz veins and some disseminated mineral. along strong NW trending shear zones in PreC rocks. Local alteration. Abundant Tertiary dikes.	Bonanza, Bullard, Centroid gp, Critic, Cuprite gp, Davis, Golden Star, Wenden gp	Az Bull 192, p.29-33; USGS Bull 451, p.115-119
Stringers and irregular veins along a strong NW-trending fault zone cutting PreC, Mesozoic and Tertiary volcanic rocks.	Eagle Tail gp, Collins, Red Bird, Adams, Camp Creek	Az Bull 134, p.142-143; Az Bull 192, p.34-36, p.145-146

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
Ellsworth, MD (sa Granite Wash)	G 3	Precambrian	Cu, Au, Ag, Pb W
Grand Central (sa Cibola, Trigo Mts, MD)	H 1	Precambrian(?)	Au, Ag
Harcuvar (Ellsworth,MD)	F 3	Other Structure	Cu, Au, Ag, Ba
Harquahala, MD (sa Little Harquahala)	G 3, 4	Detachment	Au, Cu, Ag, Pb F
La Cholla, MD (Middle Camp, MD)	G 2	Precambrian(?)	Au, Cu, Ag

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
PreC(?) quartz-siderite veins and stringers parallel to foliation (exhalite?). Some adjacent Tertiary intrusives and low-angle faulting.	Desert, Arizona Northern, Sheba, Ballif, Yuma	Az Bull 192, p. 36-39; Az OF 83-23; USGS Bull 451, p.95-104; USBM RI 5516, p.10-19; Ciancanelli thesis, U of A
Sporadic high-grade, gold-bearing quartz veins associated(?) with faults and middle Tertiary(?) granite porphyry dikes intruding PreC rocks.	Grand Central, Broadway, Jupiter	Az Bull 134, p.72-73; Az Bull 192, p.78-79, p.179-181
Irregular quartz and barite veins along strong NW trending faults in PreC rocks. Abundant Tertiary dikes.	Sheba, Bell Crown	Az Bull 192, p.149
Irregular quarts veins-desseminations in faulted-fractured Paleozoic seds. Numerous Tertiary dikes. Abundant low-angle faults (detachment).	Alaska, Blue Eagle, Hidden Treasure, San Marcos, Why Not	Az Bull 137, p.128-133; Az Bull 192, p.42-45, p.151-154; Az Circ 20; USGS Bull 451, p.104-115 And-Ham Vol.
Irregular quartz veins-stringers along fractures in PreC rocks. Strong NW trending faults.	Yum Yum	Az Bull 192, p.47-49; USGS Bull 451, p.73-86, p.156-157

3

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
La Paz, MD (Weaver, MD)	G 2	Intrusive Related	Au, Cu, Ag, Pb
Mammon (Cienega, MD)	F 2	Detachment	Cu, Au, Ag
Middle Camp, MD (Oro Fino, MD)	G 2	Other Structure	Pb, Au, Ag, Cu alunite
Moon Mountains	F, G 2	Detachment(?)- Epithermal(?)	Au, Ag, Cu
Northern Plomosa (sa Bouse, Plomosa, MD)	F 2	Intrusive Related	Au, Cu, Ag, Pb, Mn, Ba

1O

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
Veins and desseminated deposits in PreC rocks. Locally widespread quartz-sericita-pyrita alteration. Associated(?) with the Diablo quartz monzonite. Strong NW trending faults.	Goodman	Az Bull 134, p.135-136; Az Bull 168, p.25-29; Az Bull 192, p.51-54, p.158-160; USGS Bull 451,p.78-86; USGS Bull 620, p. 45-57
Breccia filling along a shear zone in PreC rocks and Tertiary intrusives. Near the Buckskin-Rawhide detachment fault system.	Mammon	Az Bull 192, p.142; USGS Bull 451, p.77-78 And-Ham Vol. Z
Disseminations and veins along strong NW trending shear zone. Associated(?) with the Tertiary Diablo quartz monzonite.	Julian sp Mariquitta, Bear, Colrio	AZ Bull 168, p.30-31; AZ Bull 192, p.56-57; 161-162 USGS Bull 620, p.52-57 Wertz thesis, UofA
Erratic quartz veins and disseminations in PreCambrian(?) rocks. Associated(?) with rhyolite plugs and detachment faulting.	Copperstone Valensuela	USGS OF 84-086, p.15
Erratic quartz veins along fractures in sheared altered Mesozoic sediments. Tertiary intrusives and detachment faults nearby. Possibly related to porphyry Cu system	Blue Slate, Little Butte, Dutchman, Old Maid	AZ Bull 137, p134-135; AZ Bull 192, p.63-67, p.165-170; AZ OF 83-24; USGS Bull 602,p.53-54. Jemmett thesis, UofA

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
Planet (Santa Maria, MD)	F2	Detachment	Cu, Au, Ag
Pride (Cienega, MD)	F 2	Detachment	Au, Cu, Ag
Southern Plomosa (Plomosa, MD)	G 2	Other Structure	Cu, Au, Ag, Pb, W
Swansea (Santa Maria, MD)	F 3	Detachment	Cu, Ag, Au, Fe, F

8(4)

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
Disseminated, veinlet and replacement mineralization in Paleozoic sediments along and above detachment fault. Much brecciation, abundant hematite	Argus gp, Mineral Hill gp	AZ Bull 137, p.127 128; AZ Bull 192, p.67-72, p.172-174; AZ OF 80-2, USGS Bull 451, p.46-67; And-Ham Vol.
Erratic hematite veins and replacement in Paleozoic sediments above detachment fault.	Arizona Pride	AZ Bull 137,p.126-127; AZ Bull 192, p.26-29, p.122 USGS Bull 451, 73-77, 122-123; And-Ham Vol.
Irregular quartz veins and replacement bodies in strongly deformed and brecciated Mesozoic-Paleozoic sediments near thrust faults. Numerous Tertiary intrusives.	Apache Chief gp, Humdinger, Iron Queen, Copper Prince, Ramsey, Poorman, Goodman	AZ Bull 137,p.134-135, AZ Bull 192, p.63-67, p.165-171, AZ OF 80-2; USGS Bull 451,p.87-95; USGS Bull 602, p.53-54; USGS GQ-841, Jemmett thesis UofA
Veinlets and replacements in Paleozoic sediments above and along detachment fault. Much brecciation and hematite.	Revenue, Signal group	AZ Bull 192, p.67-72, p.172-174; And-Ham Vol.

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
MOHAVE COUNTY			
Artillary Peak (Artillery, MD)	F3	Detachment-Epithermal	Ag, Cu, Au, Pb,
Buck Mountains	E3	Epithermal-Detachment	Au, Pb, Ag, Cu
Cedar Valley (sa Diamond Joe)	E3	PreCambrian	Ag, Au, Cu
Chemehuevis	E2	Intrusive	Au, Pb, Ag, Cu, Zn, (W)
Cleopatra (sa Rawhide)	F3	Detachment	Cu, Au, Ag,Pb

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
Quartz veins associated with rhyolite plugs and dikes that intruce the lower Artillery information (24-16-m.y.old).	Rawhide, Deer Trail, Shannon	USGS Bull 936-R; USGS Bull 961; And-Ham Vol., Sherrer thesis, SDSU; Gassaway thesis, SDSU
Quartz veins associated with NW trending zone of Tertiary rhyolite dikes.	Arizona Yucca, Palo Verde	And-Ham. Vol.; USGS OF 84-086
PreCambrian exhalite zones within greenstone horizons in general NW trencing gneissic sequence.		USGS Bull 397, USBM IC 8078
Thin, erractic quartz veins along faults in PreCambrian gneiss above detachment fault. Also disseminations in Tertiary volcanic rocks. Possible buried porphyury Cu system.	Sunrise, Scotts Well Lost Dutchman, Pittsburg, Best Bet	AZ Bull 137, p.116; AZ Bull 160; USGS Bull 1355; USGS MF-1602-A; USBM IC 8078; And-Ham Vol.
Quartz veins and quartz breccia zones in Tertiary volcanic rocks above, along detachment faults.	Unknown	USGS Bull 961, GSA Mem. 153

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
Cottonwood Cliffs, MD	D3	PreCambrian	Cu, Au, Ag, Pb,
Cyclopic (Gold Basin, MD)	C2	Detachment	Au, Ag, Pb, Cu
Diamond Joe (sa Cedar Valley)	D3	Intrusive	Ag, Cu, Pb, Au,
Eldorado Pass	C1	Detachment-Epithermal	Au, Ag, Cu, Pb
Galen	C1	Intrusive	Cu, Mo, Ag, Au, Pb, Zn
Gold Basin	B2	Other Structure	Au, Ag, Cu, Pb

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
PreCamabrian veins peripheral to PreC pluton. Some exhalite horizons associated with sericite schist.	Alabama, Walkover	AZ Bull 137, p.115; USBM IC 8078
Brecciated quartz veins within a detachment fault developed in PreCamerian granite. Associated with Crataceous granite(?).	Cyclopic, Senator, Golden Rule, Gold Belt	AZ Bull 137, p.77, USGS Bull 397, p.124-127; USGS OF 75-93; USGS of 82-1052.
Veins and disseminations in, and marginal to the 72-m.y-old Diamond Joe pluton.	Unknown	USGS Bull 397; Hanson, thesis, U of Id
Quartz veins along faults in Precamorian and Tertiary volcanic rocks above detachment fault(?).	Burrows, Young	USGS Bull 397; p.218; USGS p.374-376; USGS GQ-1394; USBM IC-6901
Disseminated mineral-ization at contact of Creataceous porphyry.	Pauly	USGS PP 374-E; USGS GQ-1394
Erratic quartz-calcite veins along faults within PreCambrian rocks. Possible lara-mide age. Local episyenite alteration.	El Dorado, Ford	AZ Bull 137, p.76-77; USGS Bull 397, p.118-123; USGS Bull 1355, p.32-34; USGS OF 75-93; USGS OF 82-1052

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
Gold Hill	E2	Other Structure	Au, Ag, Cu, Pb
Greenwood (Signal, MD; sa Lost)	E3	PreCambrian	Au, Ag, Cu, Pb
Lead Pill	E3	Detachment	Pb, Au, Cu, Ag
Lost Basin	E2	Other Structure	Cu, Au, Ag. (U)
Madrill Peak	E3	Other Structure	Au, Cu
Maynard (sa Hualapai)	D3	PreCambrian	Ag, Au, Pg, Cu, Az, (U)
McConnico	D2	PreCambrian	Au, Ag, Cu

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
Same as Gold Basin	Unknown	Same as Gold Basin
PreCambrian(?) veins or exhalite zones within altered gneiss.	Lost	USGS OF 81-503; USBM IC 8078, p.65
Erratic veins and replacements above detachment fault	Unknown	USGS Bull 961; USGS OF 81-503 GSA Mem 153
Erratiac quartz-calcite veins along faults in PreCambrian rocks. Some mineralization of PreC age, other related to Cretaceous intrusives	Scanlon-Childers	AZ Bull 137, p.76; USGS OF 75-93; USGS OF 82-1052
Tertiary veins near ENE-striking dikes.	Unknown	USGS Bull 961, USGS OF 81-503; GSA Mem 153
Erratic quartz veins (exhalites) in PreC rocks. Marginal to Cretaceous intrusive.	Various	USGS Bull 397; USBM IC 8078
Erratic PreCambrian quartz veins following foliation in gneissic rocks. Local episyenite alteration. Local breccia pipes?	Foothill, McKesson gp, Bi-Metal	USGS Bull 397, p.135-138

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
McCracken	E3	Other Structure	Ag, Pb, Au, Zn, Cu, (Ba)
Oatman (San Francisco, MD; sa Union Pass)	D2	Epithermal	Au, Ag
Owens (Potts Mountain, MD;sa McCracken)	F3	Detachment	Ag, Au, Pb, Cu, Zn
Pilgrim	C1, 2	Epithermal	Au, Ag
Rawhide	F3	Detachment	Pb, Ag, Cu, Zn, Au
Shannon Basin	E3	Intrusive	Cu
Topock	E2	Epithermal-Detachment	Au, Cu, Ag

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
Quartz-calcite-barite veins along faults cutting PreCambrian gneiss.	McCracken	USGS Bull 451, p.123-126
Tertiary epithermal quartz-calcite veins along faults in Tertiary volcanic rocks. Associated(?) rhyolite-monzonite intrusives.	Pasadena, Moss, Mossback, Gaddis-Perry, Murdock	AZ Bull 131; AZ Bull 137, p.80-100, USGS Bull 397, p.152-202; USGS Bull 743; AIME trans. v. 56, p.195-236; Thorsen, thesis, UCSB
Erratic quartz-calcite veins and replacements associated(?) with detachment fault.	Unknown	USGS Bull 397; USGS Bull 1147-A; Shackleford thesis, USC
Epithermal veins along contact of Tertiary volcanic units. Associated with low angle faults and rhyolite intrusion(?).	Pilgrim	AZ Bull 137, p.79; USGS Bull 397, p.214; USGS PP 374-E; USBM IC 6901; USBM IC 6945
Quartz and calcite veins and replacement deposits along low angle (detachment) breccia zones in Tertiary volcanics.	Various	USGS Bull 961; USGS OF 81-503; GSA Mem. 153; Shakleford thesis, USC, Sherrer thesis, SDSU
Cretaceous porphyry deposit associated with the Shannoin Basin pluton.	Unknown	USGS OF 84-086
Quartz-calcite veins associated with a major NW-striking dike swarm.	Jackpot, Gold Dome	USGS Bull 710-D; USGS MF-1602-A; And-Ham Vol.

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
Union Pass (Katherine, MD)	D1,2	Epithermal-Detachment	Au, Ag
Virginia (Mockingbird, Weaver, MD)	C1	Detachment-Epithermal	Au, Ag, Cu, Pb
Wallapai (Chloride, Mineral Park, Cerbat, MD)	C2	PreCambrian	Cu, Mo, Ag, Zn Au, Pb
White Hills (Indian Secret, MD)	C2	Other Structure	Ag, Au, Cu, Pb

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
Tertiary epithermal quartz-calcite veins along contacts and detachment faults within Tertiary volcanic and PreCambrian rocks.	Expansion gp, Union Pass gp, Roadside, San Diego gp	AZ Bull 131, AZ Bull 137, p.101-108, USGS Bull 397, p.206-211
Tertiary epithermal veins, replacements associated with brecciated zones along detachment faults(?)	Mockingbird, Red Gap	AZ Bull 137, p.78-79; USGS Bull 397, p.214-217, USGS PP 374-E; USGS GQ-1394; USBM IC 6901
PreCambrian(?) lead-zinc-silver veins in gneiss, schist. Local gold-silver veins. Porphyry Cu-Mo intrusion.	Badger, Pay Roll, Pinkham-Midnight, Merrimac, Tintic, Annie, Blanket vein	AZ Bull 137, p109-114; USGS Bull 397, p.49-118; USGS Bull 750, USSG Bull p.978-E; USGS Bull 1147-E; USBM RI 3999, USBM RI 4101
Quartz veins along faults in brecciated, altered. PreCambrian granite gneiss. Some veins have flat dips.	Prince Albert, Daisy, Grand Army of the Republic	USGS Bull 397, p.127-134

MINERALIZED AREA/ MINING DISTRICT	LOCATION	TARGET TYPE	COMMODITIES
YUMA COUNTY			
Dome (Gila City, MD)	I2	PreCambrian	W, Au, Ag
Gila Bend Mountains (sa Webb)	H4	PreCambrian	Au, Cu
Laguna (Las Flores, MD)	I1	PreCambrian	Au, Ag, Cu
Sheep Tanks	G3	Epithermal	Au, Ag, Cu, (Mn)
Yuma	I1	PreCambrian	Au, Ag

DESCRIPTION OF AREA	SPECIFIC PROPERTIES TO EXAMINE	PRIMARY REFERENCES
Erratic quartz veins parallel foliation in PreCambrian(?) schist and gneiss.	McKay, McPhaul	AZ Bull 134, p.200-210; AZ Bull 192, p.33-34, p.145
Erratic quartz veins, silicified zones in PreCambrian schist and gneiss.	Bill Taft, Lucky Strike, Yellow Medicine	AZ Bull 134, p.145-147; AZ Bull 192, p.41-42, p.164-165
Erratic, lenticcular quartz veins along shear zones parallel to schist-ocity in PreCambrian(?) rocks. Associated(?) dikes.	Los Flores Group	AZ Bull 134, p.211-217; AZ Bull 192, p.49-51, p.157-158
Quartz-calcite-manganese veins, replacements along brecciated zones in Tertiary volcanic rocks. Some zones shallowly dipping. Local rhyolite dikes.	Oakland, Davis	AZ Bull 134, p.136-141; AZ Bull 137, p.143-147; AZ Bull 192, p.72-73; p.174-175; Cousins, thesis, ASU
Erratic PreCambrian(?) quartz veins along fractures parallel to foliation in PreCambrian gneiss-schist.	Jude	AZ Bull 134, p.221; AZ Bull 192, p.79-80, p.181

Tucson, Arizona
October 24, 1974

To: Mr. J.Bruce Imswiler
IMC

From: A.J. Perry
Perry, Knox, Kaufman, Inc.

Subject: Examination POLASKY (Joanie #1-#30) CLAIMS
WEAVER MINING DISTRICT
MOHAVE CO., ARIZONA
IMC - ARIZONA #4

Location

The Joanie #1 thru #30 lode claims are located Northwest of Kingman, Arizona, in T25-26N, R20W, probably in Secs. 31, 32 and 5,6 of those townships. The area is SE of Kempie Camp, on the east side of the Black Mountains (see general location map). The claims are accessible from US Hwy 93 (Kingman to Boulder City Hwy), turning left onto a dirt road just after crossing Detrital Wash, 16.5 miles north of Grasshopper Junction.

The pediment area east and south of the Joanie claims has been roughed out with a bulldozer, making roads that conform to land subdivisions. Survey pins would seem to indicate a now abandoned attempt to subdivide.

The reported area of interest on the Joanie claims has been well excavated by dozer into a myriad of roads and shallow cuts. This area appears to be in the NW corner of the claims group.

About twenty of the 30 claims location holes were visited. Very few conform to State requirements as to depth. Polasky staked 12 claims in 1969 and the remaining 18 in February of 1970.

General Geology

The Joanie claims area covers a moderately disected pediment area extending eastward from Mt. Perkins, a prominent point in the Black Mountain Range. Polasky reported chloritized brecciated quartz monzonite intrusive with well developed stocksworks exposed in a few cuts. He reported bulk samples collected assayed from .11-.8 oz Au and .5-1.0% Cu. No work is said to have been accomplished on the property outside of the excavations noted.

The area of most intense excavation extends probably 1500' E-W down a wash centering on the site of an old cement foundation, one 10' shaft and at least one room like stope. (See Fig.2) Nine samples were collected, 8 from the area shown on Figure 2.

There are almost no natural outcrops, but dozing generally exposes bedrock beneath 2-3 feet thick aluvium over the prospected area.

The principal rocks observed are Pre-Cambrian gneiss and schist -- generally heavy in feldspar and biotite (well chloritized). Foliations observed favor the NW in strike with dips steep to the SW. Pegmatite and feldspar dikes (also PG) are common. In the shaft area a rhyolite (with locally a few qtz eyes) and a well developed flow structure is exposed.

The rhyolite intrudes the foliate sequence. Locally this rock is well silicified and has a well developed quartz veinlet stockworks. East of sample point Pal 5 the rhyolite take on a more sill like form.

Further east a feldspar biotite rock is locally well garnetized.

The rhyolite is commonly red stained. Locally it is brown stained with some casts after pyrite and possibly locally after chalcopyrite. It is often blue tinged (Cu) and locally fist sized smears of copper oxide are found in the PG in near proximity to the rhyolite contacts.

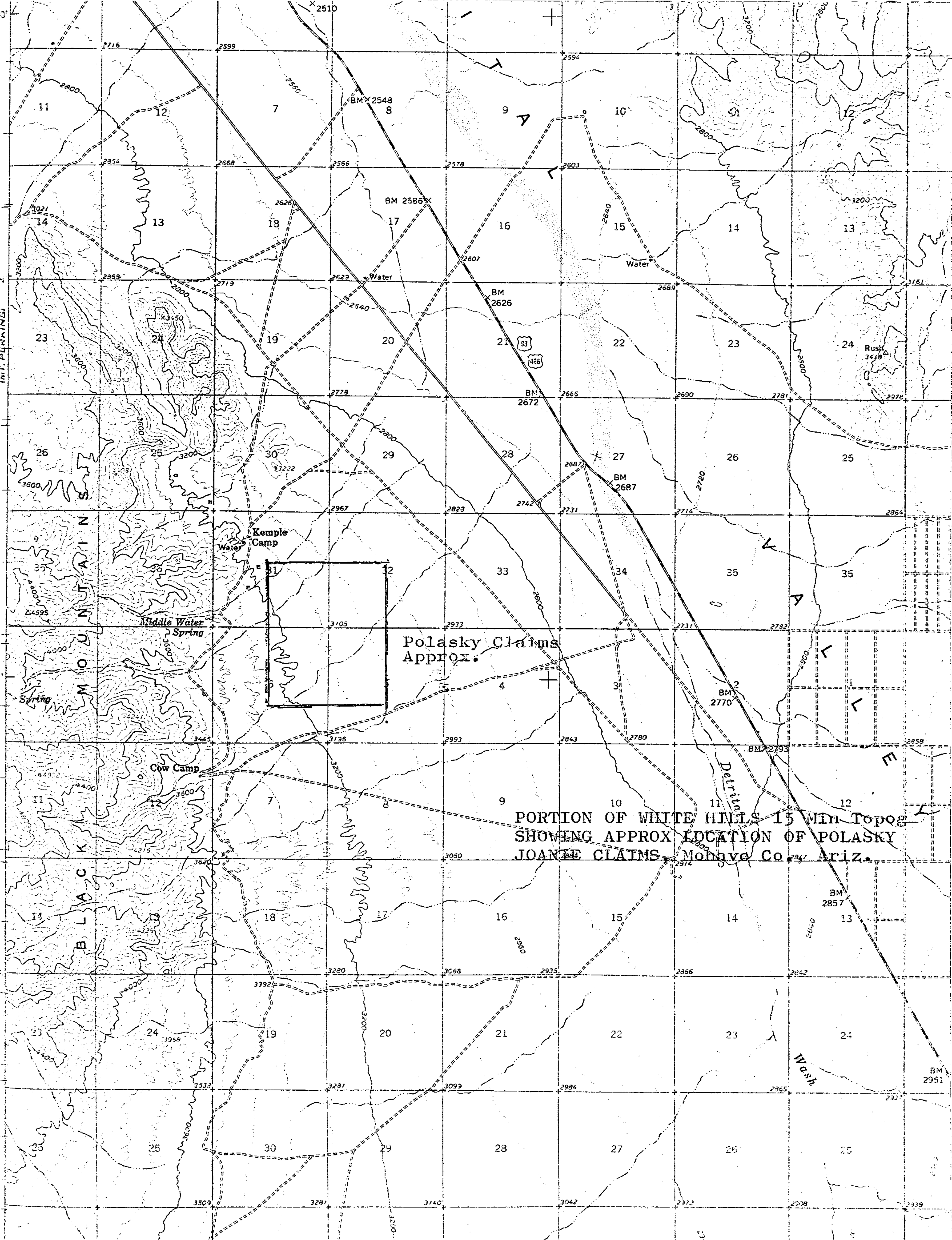
The oxide copper occurrences are in themselves of no interest and not unlike the thousands previously observed in the Pe in Arizona.

The rhyolite could be a Laramide feature but probably is not.

Nine rock chip samples were collected during the examination for geochem analyses. You are referred to Figure 2, the sample descriptions and the certificate of analysis. The better values reflect only local concentrations of copper with very minor silver and gold.

<u>Summary</u>

Showings of scattered copper oxide -- probably not related to a Laramide intrusive. The area should be viewed with some interest only if proposed airborne magnetics suggest a nearby Laramide intrusive or unless Polasky's future work uncovers more interesting features.


Polasky Claims
Approx.
PORTION OF WHITE HILLS 15 Min Topog
SHOWING APPROX LOCATION OF POLASKY
JOANIE CLAIMS, Mohave Co. Ariz.
Kemple Camp
Water
Middle Water Spring
Spring
Cow Camp
Water
Rush
Detrital Wash
BLACK MOUNTAINS
DETRITAL VALLEY

SAMPLE LOCATION MAP

KEN POLASKY'S - JOANIE CLAIMS

WEAVER MNG. DIST., MOHAVE CO. ARIZ.

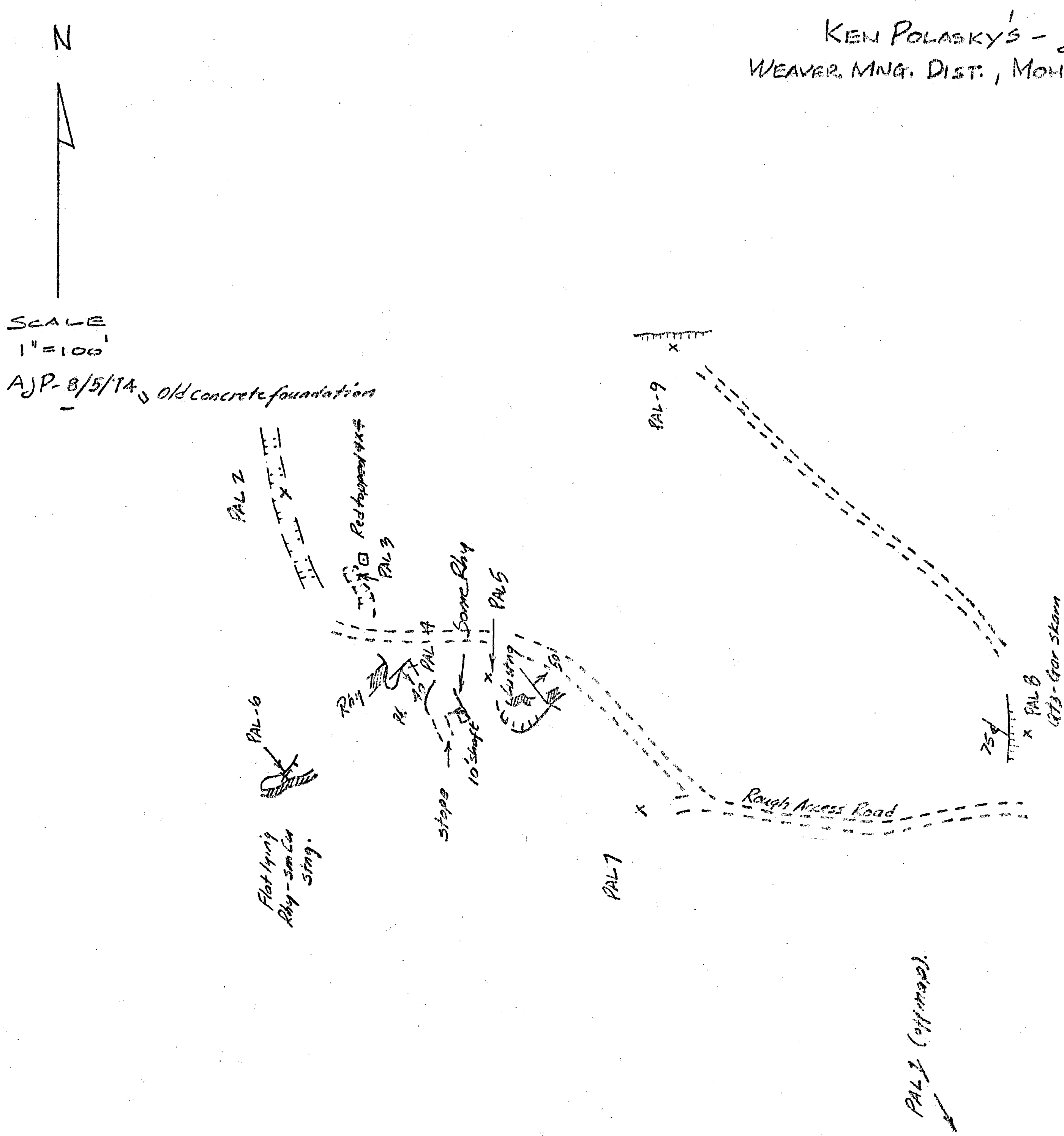


FIGURE 2

POLASKY CLAIMS - MOHAVE CO., AZ.
Sample Descriptions

8/5/74
AJP

Sample No.	Description	Au	ppm Ag	Cu
PAL-2	Brn stnd - (sheeny) chl. PG gn. from shallow cut, SE of Cem foundation.	< .02	NA	5
PAL-3	PG - fol. bkn-3, brn Fe stng after Py, w/sm Rhy? - wh. sil. micro bxa on small knob in cut spled. Faint blue and grn Cu stn., esp. to Rhy.	1.8	2.6	24,000
PAL-4	Rhy? within 2' of ct. w/PG fol. in small cut pronounced N35 near vert shrg in Rhy. Ct is sharp.	.43	NA	2,000
	In shaft cut flow text noted in spot of Rhy? bxa. E. Dipping flat structs above shaft-cut.			
PAL-5	Bxa-qtz stwks dev. Rhy?-from small dump between two cuts. (not much of this mat. noted in oc)- no sulf noted. Rhy? is everywhere so int. mxd w/PG -- poss a PG rx itself?	< .02	< .2	125
	S of PAL-5 in lg cut Rhy w/shp ct then to W overlies PG as sill < 5' tk. Ct does not X pit - (?) Sm Cu in pit walls.			
PAL-6	Muck from bot. small cut-select as are x type only Sil rhy - good qtz stwks dev - minor Cu ox stng (as wash) sm (minor indig sulf casts -- poss sm alter cpy?)	5.3		3,900
PAL-7	Brick rd stnd rhy? from 3 X 4' red patch bottom small scraping - suff by PG	< .02		105
PAL-8	Qtz - garnet (slm) skarn. wh - somewhat sim in genl app to Rhy sm minor rd lim - surr by PG sch.	< .02		10
PAL-9	Random grabs - side of cut. Mxd (chl.) biot sch. and a plag. biot, gar peg sch (qtz?).	< .02	< .2	30

SKYLINE LABS, INC.
Hawley & Hawley, Assayers and Chemists Division
1700 W. Grant Rd., P.O. Box 50106, Tucson, Arizona 85703
(602) 622-4836

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

CERTIFICATE OF ANALYSIS

ITEM NO.	SAMPLE IDENTIFICATION	Au ppm	Ag ppm	Cu ppm
1	PAL - 1	<0.02	<0.2	10
2	2	<0.02		5
3	3	1.8	2.6	24,000
4	4	0.43		2000
5	5	<0.02	<0.2	125
6	6	5.3		3900
7	7	<0.02		105
8	8	<0.02		10
9	PAL - 9	<0.02	<0.2	30
10	BLND - 1	<0.02	<0.2	
11	2	<0.02	<0.2	
12	3	<0.02	<0.2	
13	4	0.34	1.0	
14	BLND - 5	<0.02	<0.2	

Polasky Claims
Mohave Co., Az.

TO:
Perry, Knox & Kaufman, Inc.
P. O. Box 12754
Tucson, Arizona 85732

Attn: Mr. A. J. Perry

REMARKS:
Trace analysis

CERTIFIED BY: William L. Lehmbeck

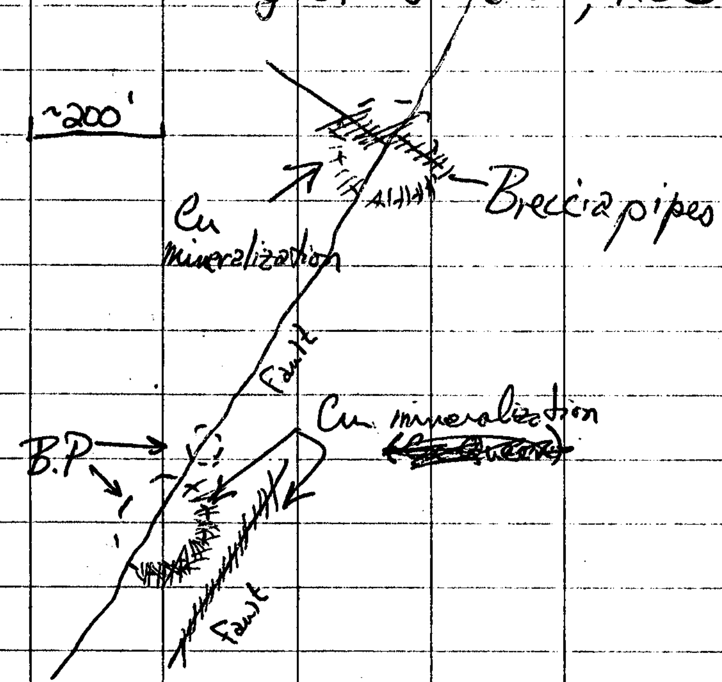
9425
LEHMBECK
ARIZONA U.S.A.

DATE REC'D:	DATE COMPL.:	JOB NUMBER:
8/7/74	8/16/74	741546

Copper Queen Area -

Cu Queen is frac. controlled Cu deposit in Kaibab ls. w/ minor Fe, Mn oxides and U. Pit looks low grade and mined out.

Breccia pipes may be related to frac. controlled deposits - may be along fracs or major faults + have circulated mineral. waters into fracs.



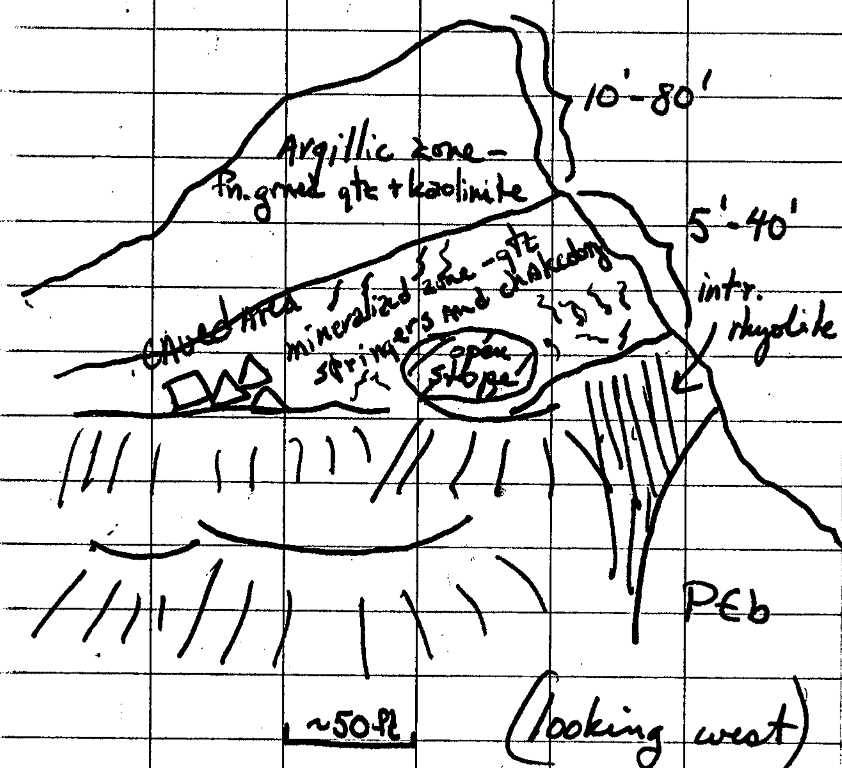
Frisco Mine

Appears to be preserved h.s. horizon at contact of P€b + Tert. intrusive rhyolite. Au-miner. frac. zones extend from base of Tert. for a thickness of 5' to 35'. Advanced argillic alt. caps deposit forming caving overhangs.

Tight drill pattern in open cut. Much recent caving of argillic zone. Frac. zone w/ Au was "zone of boiling"; abun silica veining, hydro. qtz + chalcedony, minor opal. Abun. hematite string. Large stoped area in upper portion of vein; stope is ~ 35' high, w/ shafts off it — Present open cut is causing caving of argillic zone.

May have good potential for production of another 300,000 tons of 0.2 oz/ton Au. Overburden removal may be problem, but S.R. probably not more than 3:1.

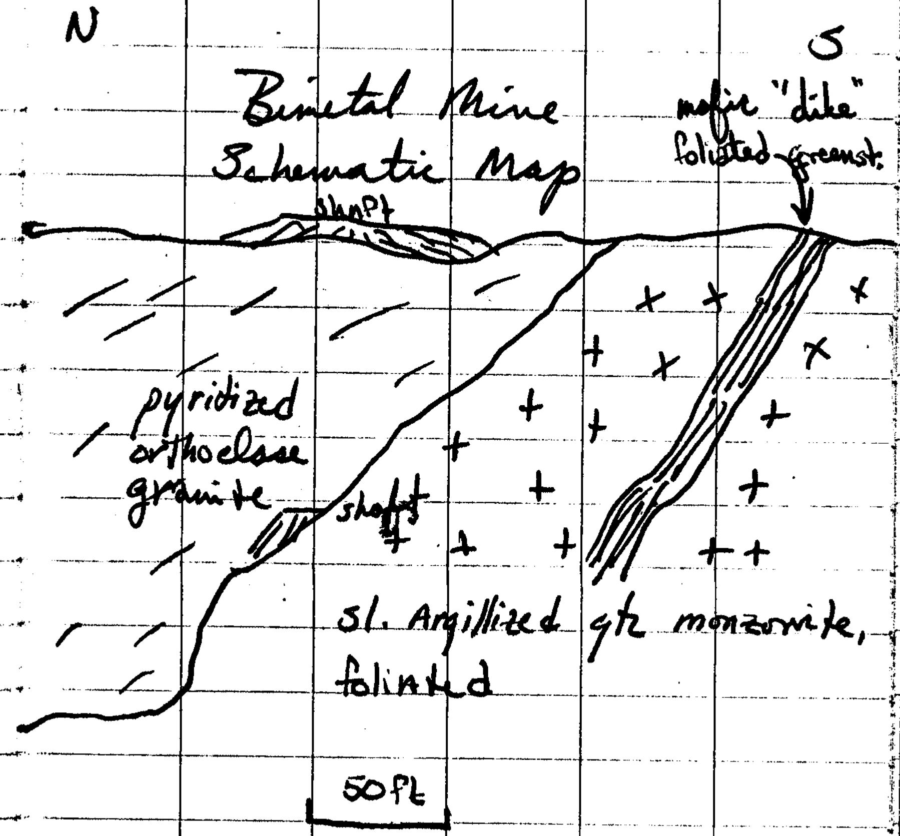
Frisco Mine



Bimetal Mine

Au contained in pegmatitic appearing orthoclase rich granite – Au is apparently in pyrite cluster which are v. abundant. Granite is highly frac'd w/ many veinlets qtz w/ hematite and minor Mn. Minor fluorite noted. Open cut is quite large and nearby shaft indicates reserves may be significant, in 100,000–200,000 range. Nearby railroad may be problem in development of this property.

Some exposures suggest this may be PЄb stratabound Mineral Ridge type granite – may be metasomatic rock produced from high Alumina



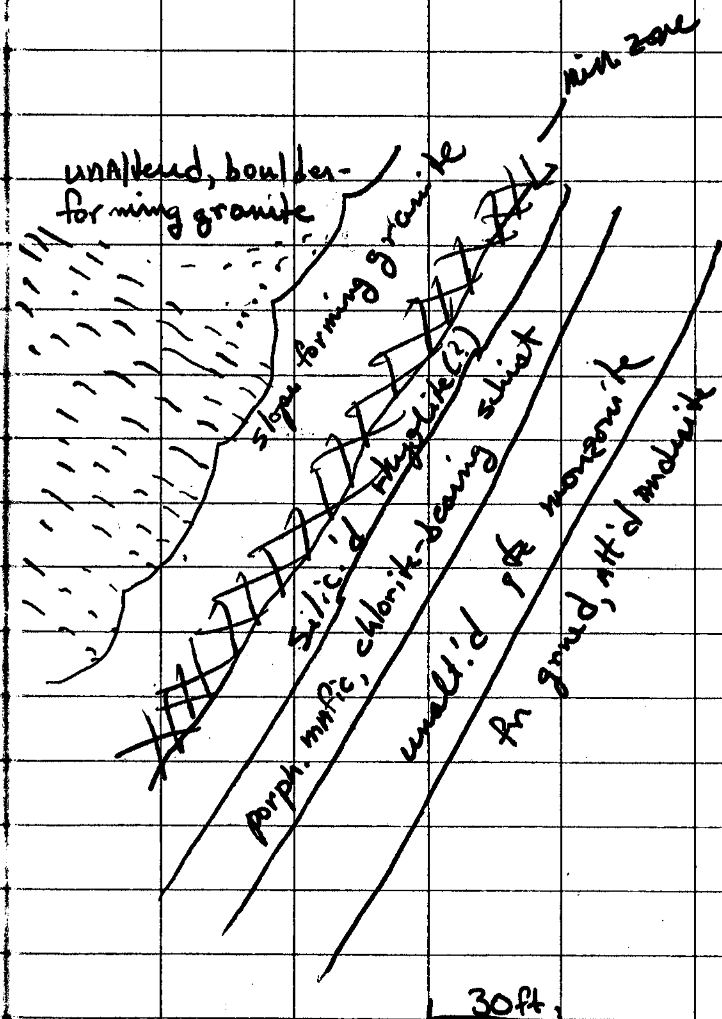
rock type like h.s. Orthoclase, very pink to deep red felds, has replaced much rock and even lines fracs. Only minor epidote noted.

Boulder Spring Area

Area of Au-bearing pegmatitic orthoclase-rich granites.
Stratified nature of rock types adds to suspicion that these are metamorphosed volcanics.

Mineralized zone extends along a poorly exposed, slope forming granite. Piles of granitic rock in area show penetrative foliation rather than flow foliation of true intrusive rock.

Min. zone is hematite-stned granitic rock, some chlorite dikes and minor qtz-veining w/ few sulfides. V. poorly exposed.
Zone is about 6'-10' across.



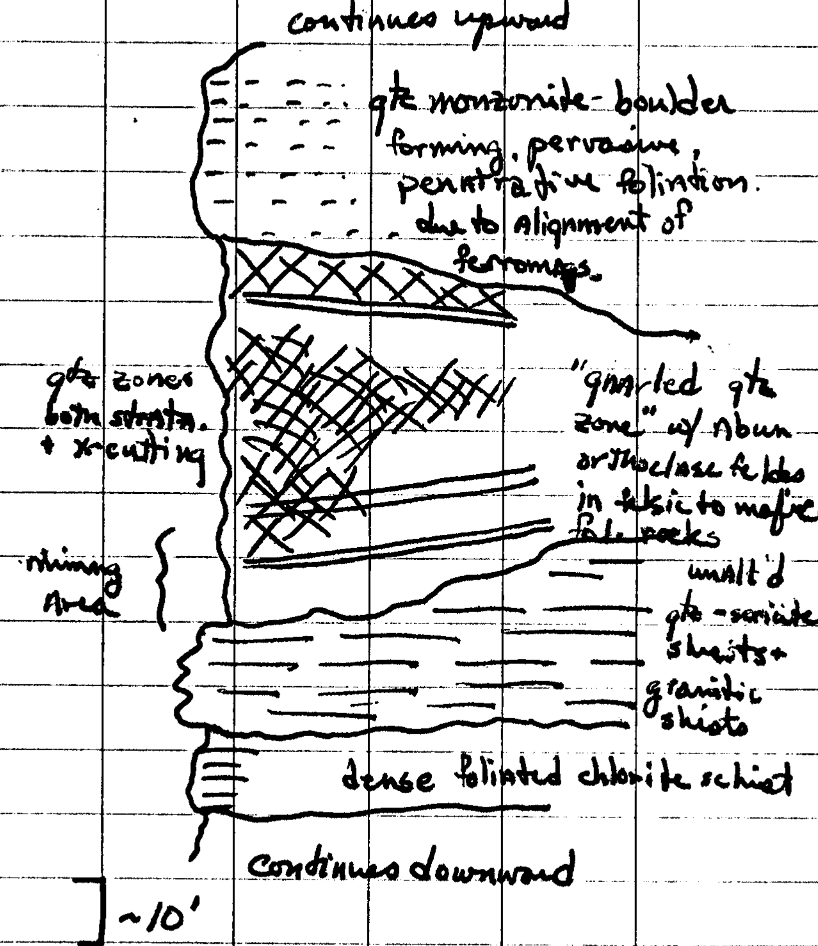
Boulder Creek Mines

Similar to Boulder Spg but most prospects poorly exposed - one open cut shows only ore piles + minimal exposure of Bimetal Mine type granite At base. Areas of mineralization Are localized in slope forming granite - boulder forming granite is not mineralized.

W/in slope forming unit Are two types of deposits - ① those Assoc'd w/ pegmatitic orthoclase granite, Au in pyrite, minor qtz veining, fluorite.

② Bulbous zones in gneissic, foliated + highly meta'd. felsic rocks; zones Are v. qtz rich, w/ Abun. ortho. feldo., Abun. pyrite. Minor

Boulder Crk. Schematic Section



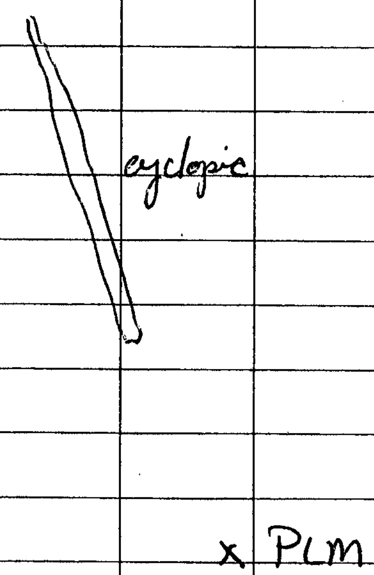
epidote + Fe - staining. Qtz lodes show both stratiform and crosscutting relationships. Abun. replacement of rock-types along fracs. by orthoclase.

PLM prospect

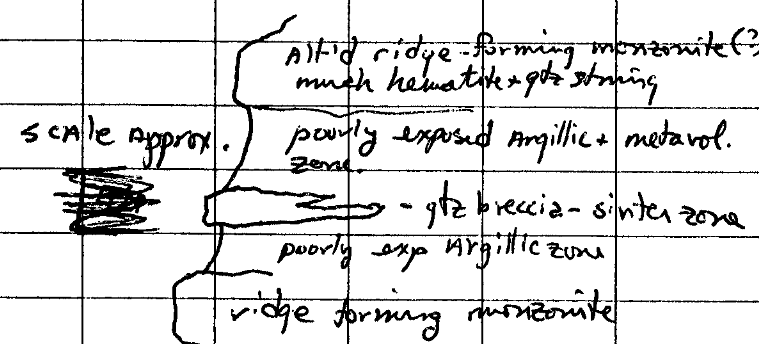
Relatively flat lying to steeply dipping reddened granitic appearing rock w/ abun. silica, Fe-staining (ironstone?) - Fluorite, sulfides (pyrite) noted. V. poorly exposed, tho thickness may be as much as 30'. May be extension of Cyclopic (?)

Cyclopic

Au values from what appears to be mineralized volcanics in pЄb rocks. Several small pits dug for ~ 4000' along strike. Much ground disturbance



Cyclopic Section, V. Schematic



makes exposure poor, but there
is a series of Argillic and
silic'd zones apparently interbedded
w/ metavolcanics (mafic + felsic)
Min. zone appears to be as
much as 40' across. Much
recent drilling in hanging
wall zone. Placer potential may be
v. good. Wide zone of apparent
mineralization amenable to open pit.

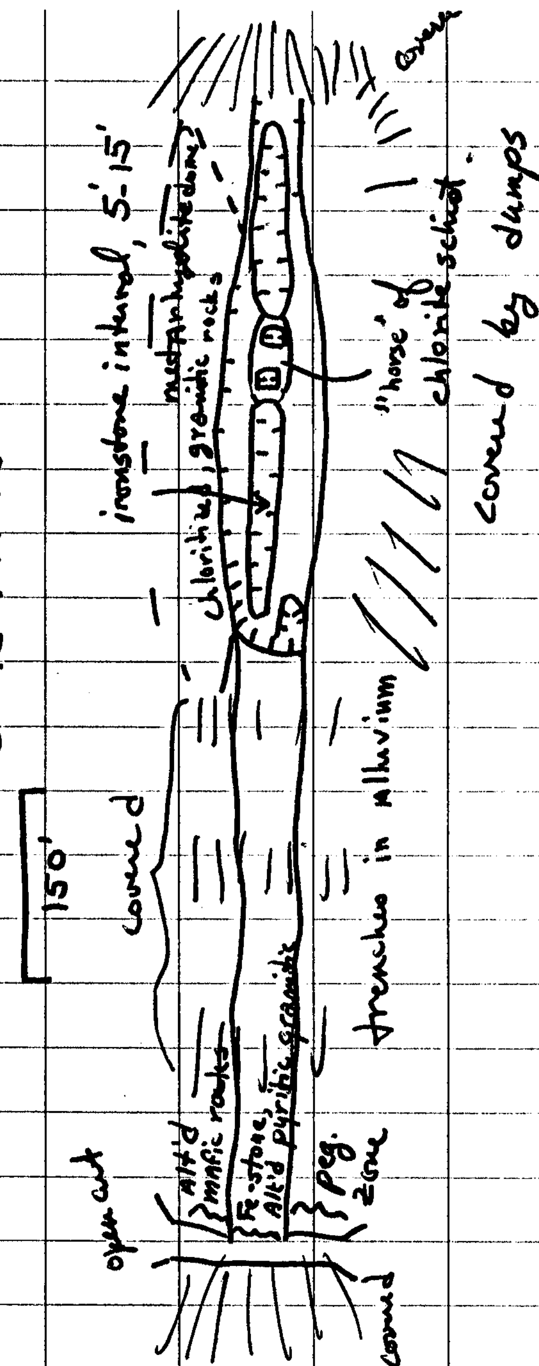
Gold Bug

Au-mineralization in PЄb Age ironstone interbedded w/ mafic + felsic metavolcanic rocks. Mined extensively in central portion; may have strike length potential. May be related to felsic dome in sequence. May be other Fe-formations in this stratigraphy worth prospecting. Covered interval along strike w old workings may have potential in 10,000 - 100,000 ton range.

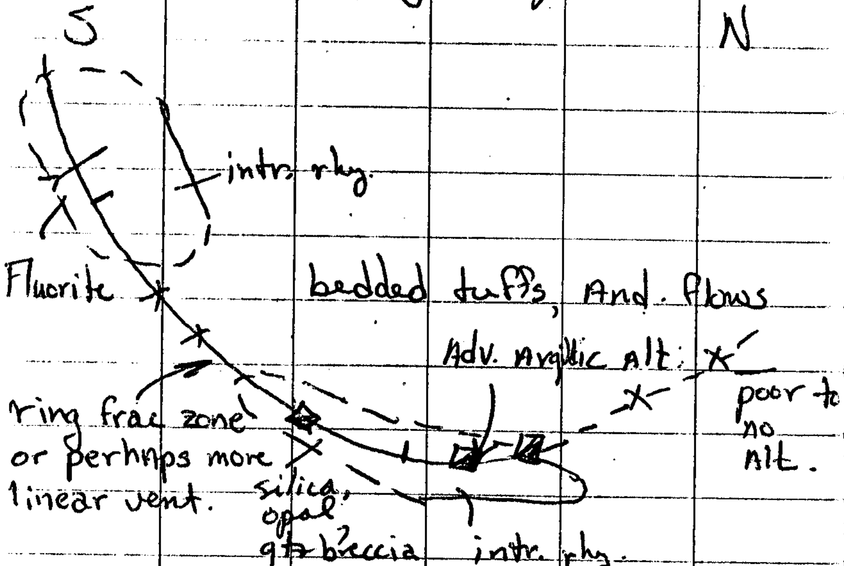
Complex geol. indicates a variable terraine - prob. a vent-dome complex w/ nondetrital sedo.

GOLD BUG GEOLOGY

SCHEMATIC



Hidden Valley Prospect – Secret Pass Area – Owl Pass Quad



Mineralized volcanotectonic fracture zone intruded by silic'd, pyritized rhyolite. High-grade Au produced from Adv. Argillic zones, w Abun. hematite. Rhyolite is flow foliated + obviously intrusive. Min. Appears to be podiform Along strike, changes slightly in style to south. May have bulk potential but pay zone near old workings may not be more than ~6' thk. May be multiple targets on this feature, Fluoritized Area may be of sl larger extent. Breccia pipes may be on this struc; qtz. breccia At central prospect remin. of b.p. material.

Santa Fe claims

Reddened, sl silicified Areas (linear features) in Ash flow tuffs. N. of Area of dome-like features, Along N-S trending zone. Rocks Away from struc. zone unAltered.

Will Wilkinson has complete thesis

RUBIDIUM-STRONTIUM GEOCHRONOLOGY AND TRACE ELEMENT GEOCHEMISTRY OF PRECAMBRIAN ROCKS IN THE NORTHERN HUALAPAI MOUNTAINS, MOHAVE COUNTY, ARIZONA

by

Edward Joseph Kessler

A Thesis Submitted to the Faculty of the

DEPARTMENT OF GEOSCIENCES

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 6

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF ILLUSTRATIONS

LIST OF TABLES

ABSTRACT

Six Precambrian rock bodies in the northern Hualapai Mountains were dated by the whole rock rubidium-strontium isotope ratio method and range in age from approximately 1800 to 1100 m. y. A complex of folded gneisses and schists were intruded by a granodiorite pluton about 1800 m. y. ago. This event was followed by intrusion of a granitic magma about 1500-1600 m. y. ago. These rock bodies were then foliated prior to a major intrusive event 1300-1400 m. y. ago. This event resulted in the intrusion of at least three magmas into the metamorphic complex. Younger pegmatites intruded the region about 1100-1200 m. y. ago. These ages are generally in agreement with those determined by other workers.

Trace element studies indicate that four of the rock units can be distinguished on the basis of their rubidium, strontium and zirconium content. The trace element studies along with isotopic studies negate closely related origins for all but two of the units investigated. High strontium rocks are low in $^{87}Sr/^{86}Sr$ initial ratios suggesting a mantle origin for these rocks. Low strontium rocks have enriched $^{87}Sr/^{86}Sr$ initial ratios suggesting some amount of a crustal component in their parent magma.

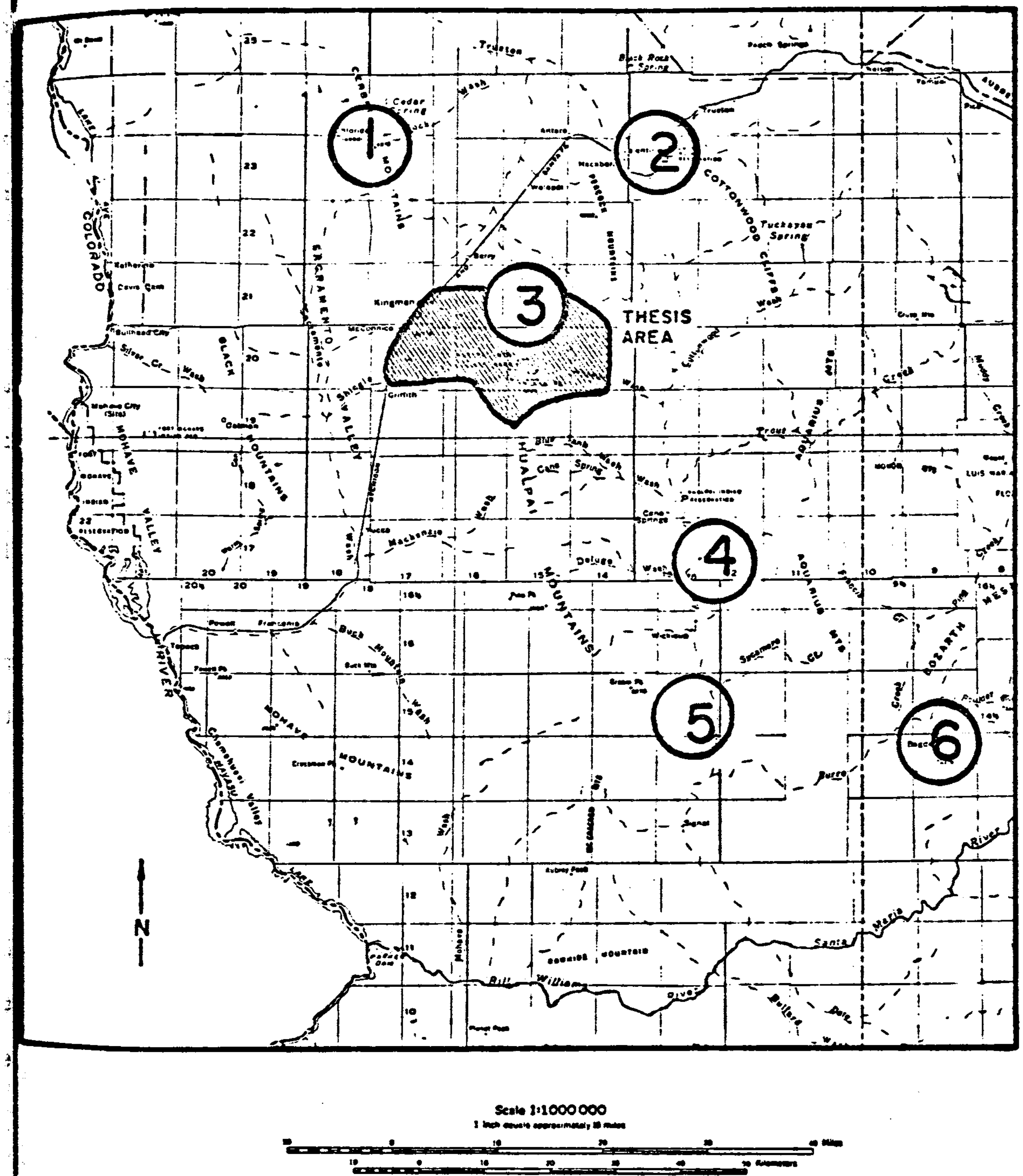


Figure 2. Location Map of Precambrian Isotopic Ages in Northwestern Arizona. -- Base Map from U. S. G. S. 1:1,000,000 "State of Arizona" Map; see Table 1 for data.

s.

use of

eld or by

es

tment

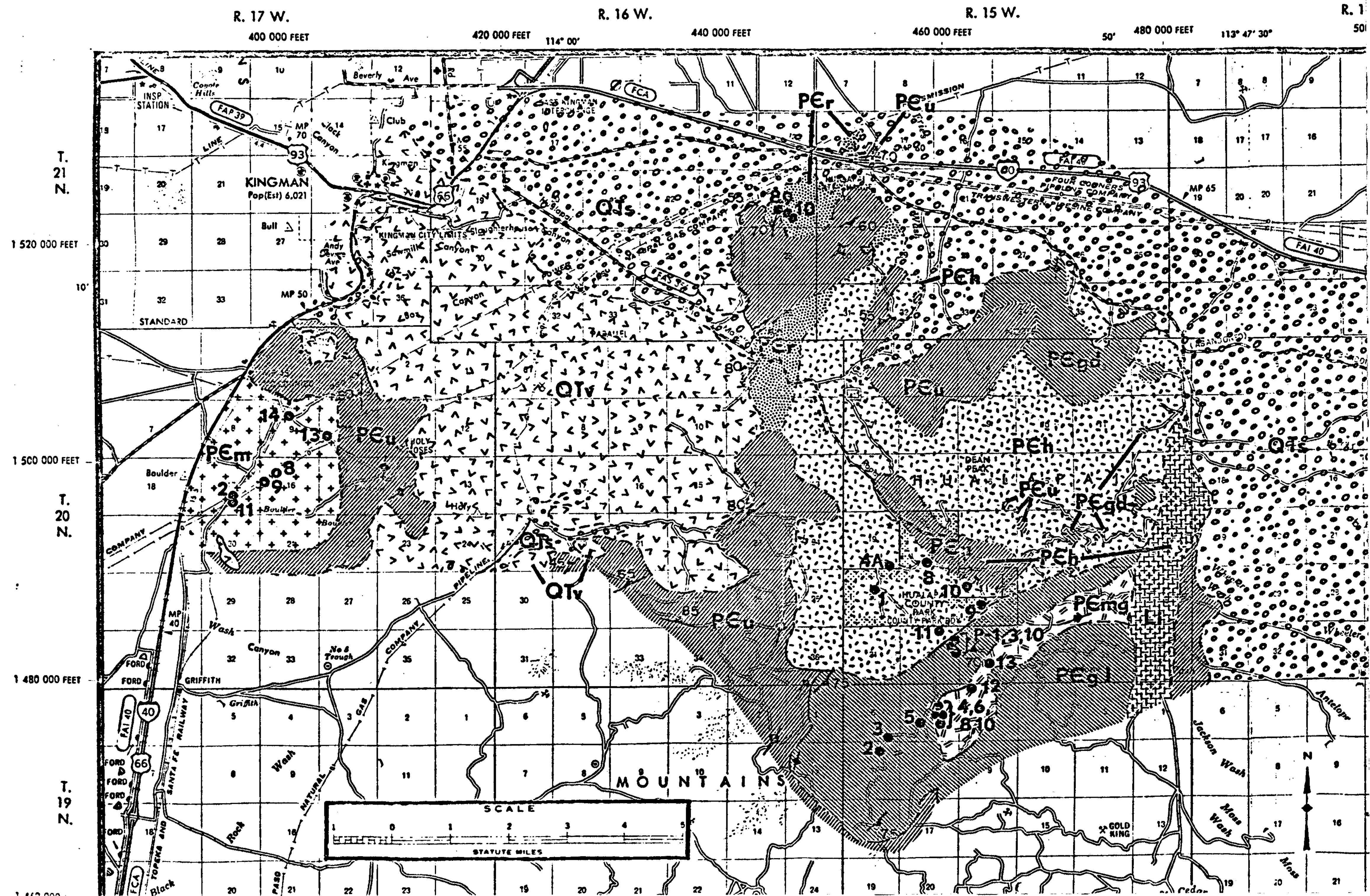


Figure 3. Geologic Map of the Northern Hualapai Mountains.

Explanation:

Symbol	Unit	Age
Qal	Alluvium and Sedimentary Rocks	Cenozoic
QTv	Undivided Volcanic Rocks	Cenozoic
Ti	Intrusive Stock	Laramide
PЄmg	Medium-grained Granite	Precambrian
PЄm	Holy Moses Granite	Precambrian
PЄh	Hualapai Granite	Precambrian
PЄr	Rattlesnake Hill Granitic Gneiss	Precambrian
PЄgd	Granodiorite Gneiss	Precambrian
PЄu	Undivided Gneiss and Schist	Precambrian

——— Contact established in the field

- - - - Contact inferred in the field or established by use of aerial photography

.... Contact projected without verification in the field or by use of aerial photography

o5 Sample location and number (p=pegmatite samples) Locations given in Appendix B

70 Foliation with dip

Vertical foliation

Approximate strike and dip of foliation

Base Map is General Highway Map--County Series published by the Photogrammetry and Mapping Division of the Arizona State Highway Department

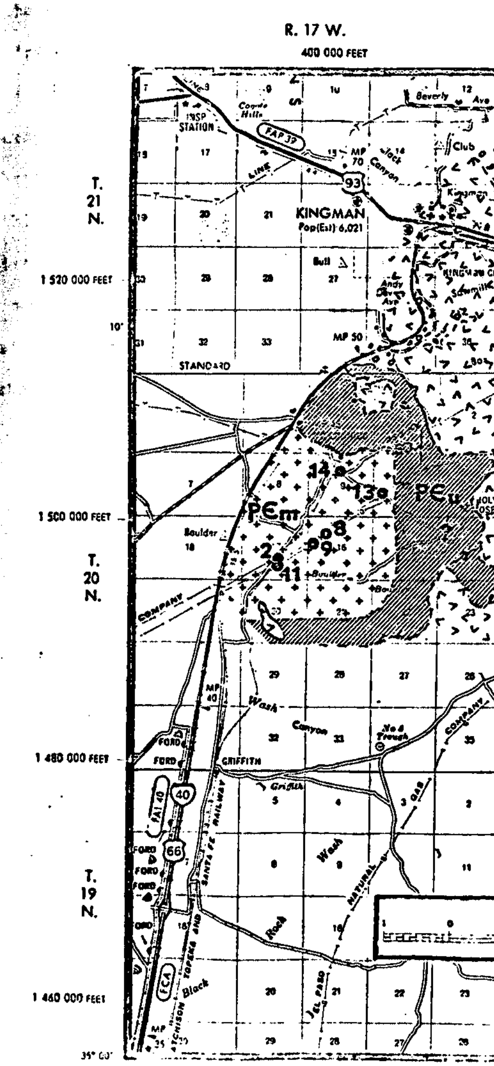


Figure 3. Geologic Map of the Nor

Pegmatites

There appears to be at least two different ages of pegmatite and aplite dikes throughout the mapped area. Some intrude the granodiorite gneiss and are folded. This suggests premetamorphic emplacement. There are also unfoliated pegmatites which intrude the granodiorite gneiss and the Hualapai granite and form sharp contacts with these units. In the northwest quarter of Section 35 T.21N., R.15W. foliated pegmatite dikes are crosscut by unfoliated pegmatites. Because some pegmatites do not accept foliation readily, it is difficult to determine their chronological relationship to a metamorphic event.

The pegmatites sampled are whitish coarse-grained dike rocks intrusive into the granodiorite gneiss. They are of quartz monzonite composition (see Table 2) and contain phenocrysts of orthoclase and microcline over 100 millimeters in length. They also contain books of biotite over 10 millimeters in diameter as the dominant mafic accessory. The largest pegmatite body sampled is about ten meters across and is too small to appear on the geologic map (Figure 3). However, the locations of the dated samples are indicated.

Laramide Intrusive

A large light grey medium-grained equigranular intrusive stock is the only Laramide rock mapped in the area of interest. Most of it was mapped by Vuich (1974) at a scale of 1" = 1000 feet. He suggests it is a continuation of a Laramide instrusive shown on the Geologic Map of Mohave County (Wilson and Moore 1959). Since this rock body contains disseminated copper and molybdenum mineralization not unlike other known Laramide intrusives in the state, Vuich's age assignment seems reasonable. The mapped equigranular stock outcrops in the eastern portion of the region and contains inclusions of the Precambrian granite and gneiss. This unit consists of euhedral to subhedral biotite, potassium feldspar, plagioclase and anhedral to subhedral quartz. The average grain size is between two and five millimeters.

Cenozoic Rocks

Cenozoic rocks of varying thicknesses cover a Precambrian surface of moderate relief along the northwestern and western flanks of the range. Sedimentary materials are most extensive on the eastern flanks of the range.

Tertiary and Quaternary Volcanics

Tertiary and Quaternary volcanics and lesser amounts of interlayered sedimentary material aggregate up to several hundred feet thick and cover an extensive area on the western and northwestern flanks of the range. They range in composition from rhyolite to basalt. The mapped unit includes a Tertiary intrusive which appears on the Geologic Map of Mohave County (Wilson and Moore 1959).

Alluvium and Sedimentary Rocks

This unit consists of silts, sands, gravels and conglomerates of Tertiary and Quaternary age and is most extensive on the eastern flanks of the range. It includes weakly consolidated materials which have been tilted up to 30° to the west. Some of the tilted strata contain volcanic

A GEOLOGIC RECONNAISSANCE AND MINERAL EVALUATION
WHEELER WASH AREA, HUALPAI MOUNTAINS,
MOHAVE COUNTY, ARIZONA

by

John Steven Vuich

A Thesis Submitted to the Faculty of the

DEPARTMENT OF MINING AND GEOLOGICAL ENGINEERING

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE
WITH A MAJOR IN GEOLOGICAL ENGINEERING

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 4

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF ILLUSTRATIONS

ABSTRACT

A geologic reconnaissance of the Wheeler Wash area was performed to evaluate the region for the potential occurrence of economic mineral deposits.

Basement metamorphic rocks have been intruded by Precambrian and Laramide (?) granitic plutons. Much of the base and precious metal mineralization is thought to be associated with the younger intrusions. Northwest trending structures are the most favored for sulfide mineralization. Other major structural trends strike north-south, east-west, and east by northeast. Regionally there is a notable metallogenic zoning of vein deposits. The innermost zone contains molybdenum-tungsten veins. Outward, the zones progress to copper-molybdenum, lead-zinc-silver, and gold-silver bearing veins.

Mineralization, metallization, and wall rock alteration suggest that several locations contain mineralized bodies that typify a porphyry copper-molybdenum deposit. It is concluded that these mineralized exposures represent either two separate deposits or a single deposit that has been displaced approximately 4,500 feet right laterally along an east-northeast fault zone.

Two other areas are deemed favorable for exploration. A photo linear analysis suggests a possible anomalous structural zone north of, and adjacent to the Wheeler Wash study area. A buried pediment area to the west is inferred to possibly contain a faulted segment of one of the exposed mineralized bodies and possibly host other concealed deposits.

Exploration programs are proposed which would evaluate the three areas more thoroughly.

CHAPTER 7

ECONOMIC GEOLOGY

The exposed mineralized zone, as delineated by a nearly pervasive, pyritic halo (Fig. 6; Figs. 7 and 8, in pocket) is an elliptical shaped area whose long axis is approximately 20,000 feet in length and strikes north-northeast. Width dimensions for the pyritic halo average 10,000 feet near the south end, but narrow to 3,000 feet in the north.

Four areas of concentrated economic mineralization are interpreted from the Geologic and Alteration Maps (Figs. 2 and 7). Their dimensions range from 1,000 x 1,500 feet to 2,000 x 6,000 feet. These mineralized areas are shown (Figs. 6 and 8) as overlapping zones of hydrothermal alteration and sulfide mineralization that occur as veinlets and disseminations. The majority of mining properties with recorded production and the larger mineral prospects lie within the four areas outlined in Figs. 6 and 8.

Primary Mineralization

Hydrothermal mineralization exists as large fissure veins, veinlets, and disseminations. Three stages of mineralization are suggested from field observations, from drill core examinations which indicated some cross cutting relationships, and from the early reports of Schrader (1909) and Wilson (1941).

Quartz veins containing pyrite, molybdenite, and often containing wolframite and scheelite, with local occurrences of chalcopyrite,

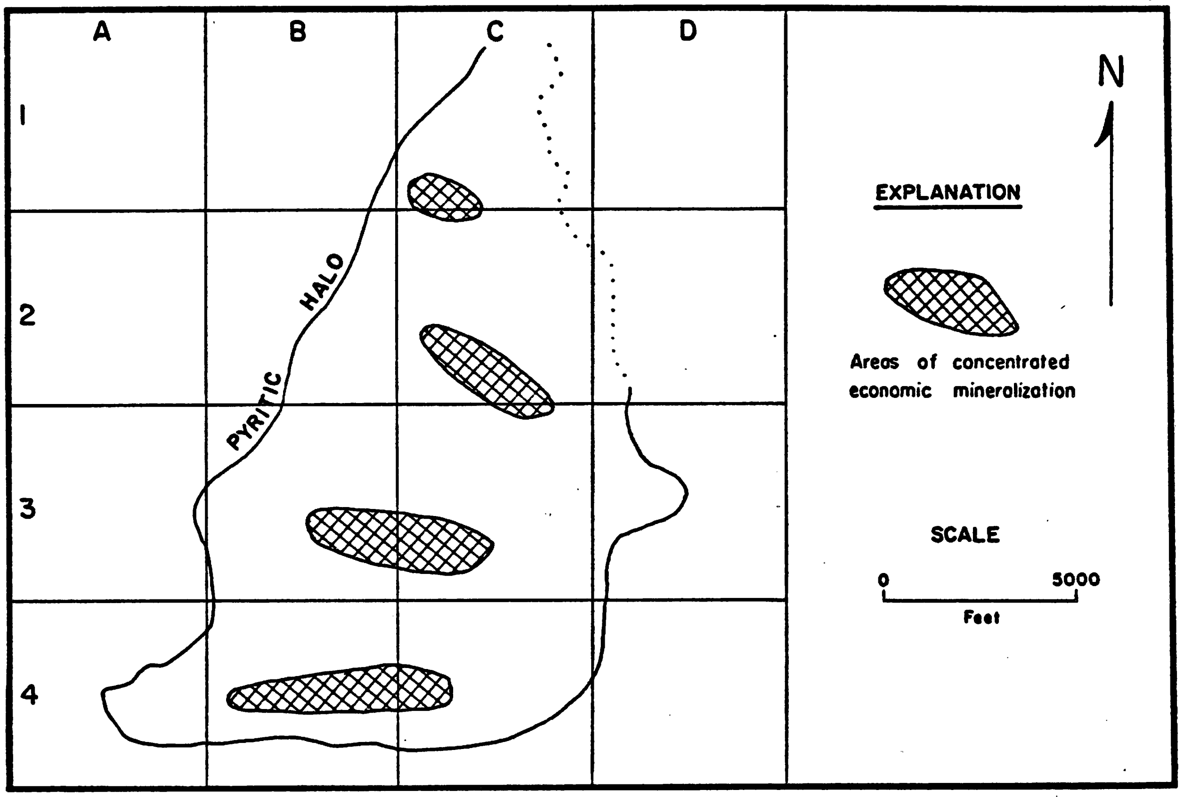


Fig. 6. Sketch Map Simplifying Figs. 2, 7, and 8

comprise the first stage of mineralization. Veins of the first stage strike in all of the major structural directions and dip steeply. They are weakest in the east-west striking directions and possibly strongest in the north-south direction. North-south quartz veins up to four feet in width, sometimes containing recoverable amounts of tungsten and molybdenum, occur in the eastern half of grids B-3 and 4 (Fig. 2) and have considerable exploratory work in the way of small adits and test pits performed on them. A possible separate stage of barren quartz or quartz-pyrite mineralization may exist but its distinctness as a separate stage and its relationship to the other mineral stages are not known. Dale (1961, p. 90) reports that veins of similar description to the barren quartz veins parallel what is described here as veins of the first stage. By structural association, the barren quartz or quartz-pyrite vein system may be a phase of first stage mineralization.

The age of formation for these first stage minerals has not been resolved and arguments for Precambrian, Laramide, or both ages can be presented. Anderson, Scholz, and Strobell (1955, pp. 79-80) concluded that the tungsten mineralization of the Bagdad area, 50 miles southeast, was associated with the intrusion of the Precambrian Lawler Peak granite. Wolframite with local associations of scheelite occur in northwest striking quartz veins up to 12 feet wide. Virtually all the tungsten mineralization in the Hualpai range nearest the thesis area is hosted in Precambrian rocks.

With regard to tungsten mineralization at Mineral Park, 25 miles northwest, Eidel, Frost, and Clippinger (1968, p. 1270) concluded that the earliest mineralization containing trace amounts of molybdenite, wolframite, and pyrite formed with large quartz masses during late stage crystallization of the central core of the Laramide, Ithaca Peak quartz monzonite magma. Tungsten mineralization is also associated with the Laramide (?) pluton in the thesis area at the Telluride Chief (Standard Minerals) mine (Wilson 1941, p. 15).

A third possibility for the present occurrence of tungsten mineralization would be for the Laramide activity to have superimposed its own mineral deposition over a Precambrian tungsten occurrence with a potential to have partially or completely remobilized the tungsten metallization locally.

Second stage mineralization consists of quartz-pyrite-molybdenite-chalcopyrite veins and veinlets and local sulfide disseminations. In more intensely mineralized areas second-stage veins and veinlets strike northwest and northeast, dipping steeply. The northwest direction appears to be the overall preferred direction. Veinlets and pervasive disseminated sulfides are localized in four separate areas as outlined in Fig. 8. Often there is a distinct decrease in intensity of mineralization in topographically high areas relative to mineral intensity in canyon bottoms. Therefore, the four intensely mineralized areas of Fig. 8 may be separate in part due to an erosional effect. As was suggested earlier, post-mineral; right lateral strike-slip movement along the Soap Wash fault zone may account for some separation. About 70 per cent of the sulfides occur as fracture fillings.

Third stage mineralization of veins, and locally veinlets, containing quartz, pyrite, chalcopyrite, galena, and sphalerite are more prominent in areas peripheral to the mineralized zone. Although vein strikes in all major structural directions are represented, the preferred strike is northwest. Properties outlying the thesis area with recorded production (Schrader 1909, pp. 140-141) indicate that the veins of mineralization similar in description to the third stage veins also accounted for much of the gold and silver production in the district. Arizona Bureau of Mines file data and Wilson (1941, p. 14) also record precious metal production in lead-copper-molybdenum ore from the Standard Minerals mine. Surface mineralization at the Standard Minerals property, however, did not indicate the presence of mineable copper-lead bearing veins at depth.

District-wide, the most favored strike direction for mineralization is northwesterly. All rock types except the noted peripheral diabase dikes contain sulfide mineralization. Veinlets and veins range in width from 0.05 inch to nearly 6 feet. In the intensely mineralized areas veinlet density is estimated to average one veinlet per inch.

Chalcopyrite is probably the second most widely distributed sulfide next to pyrite. Molybdenite is more fracture controlled and is not seen to be pervasively disseminated. Much of the disseminated pyrite in the strongly mafic Precambrian quartz diorite gneiss and granite is seen to replace biotite. Actual total sulfide content over the more strongly mineralized zones of Fig. 8 has not been quantitatively determined, but a visual estimate indicates a maximum of 5 per cent and a reasonable average of 3 per cent. This average 3 per cent sulfide content contains a mineral ratio of pyrite:chalcopyrite:molybdenite that is estimated to be 15:2:1. Rough calculations indicate metal concentrations in these areas might average as high as 0.15 per cent copper and 0.10 per cent molybdenum. Outward from these zones the estimated total sulfide content diminishes to 1 per cent at the limit of pyritization (Fig. 8) where pyrite comprises virtually all of the sulfide mineralization.

Wall Rock Alteration

Hydrothermal alteration of wall rock in the Wheeler Wash area exists for the most part as envelopes enclosing fracture filled systems. In many observations, fresh rock is seen between veins. Outward from a vein, the alteration extends from 0.1 inch to a few inches. Localized exceptions occur in areas where vein/veinlet density allows for overlapping of outer alteration envelopes. In such instances, pervasive alteration is generally consistent with the outer envelope.

Fig. 7 shows alteration products in wall rock for the areas traversed during geologic mapping. As with the Geologic Map (Fig. 2) blank areas do not necessarily indicate a lack of outcrop exposures, but rather that the area was not mapped due to difficult accessibility or a lack of field time.

With regard to those alteration products listed in Fig. 7, a few comments of clarification are presented. Rocks examined during mapping were subject to various stages of weathering. Whenever possible, the least weathered specimen was examined for wall rock alteration. It should be considered however, that some clay development on feldspars and mica (sericite)-like minerals can be found in a supergene environment and be mistaken in hand specimen for argillic and sericitic alteration, respectively.

A pyritic zone appears to cover the district. In Fig. 7 the pyritization was defined by actual observations of pyrite, iron oxide pseudomorphs after pyrite, and other iron oxide stained casts and fractures which visually were identifiable as staining after pyrite and which did not have stain characteristics similar to those seen on weathering, mafic rock-forming minerals. Inferred positions of the outlined pyritic halo were determined by using colors distinctive of iron oxide after pyrite as a guide and plotting the observable extent of those rocks stained by the distinctive colors. All of the pyritic halo in unmapped areas was defined by this process.

Alteration Zones

Four alteration zone boundaries are depicted (Fig. 8) within the pyritization halo. These zones designate the general extent of each alteration mineral assemblage used in megascopic identification of a particular zone. Thus, any alteration envelope enclosing a sulfide vein may contain one or more alteration assemblages, but when certain assemblages are no longer dominant or cease to exist, it is considered to be the limiting extent, hence the zone boundary, for that particular alteration assemblage. As with defining the zones of intense mineralization, the topographic effect, i.e., the depth of erosion in local areas, may mask continuity between alteration zone boundaries. Field observations did not indicate that rock type interfaces had significant

EXPLANATION

Symbol	Unit	Age
al	alluvium	Cenozoic
Lqmp	quartz monzonite porphyry	Laramide (?)
Lqm (ap)	quartz monzonite, with aplite dikes	Laramide (?)
Ka	andesite dikes	Cretaceous(?)
db	diabase	Precambrian
gr (ap)	granite, with aplite dikes and pods	Precambrian
qd gn	quartz diorite gneiss	Precambrian
gn/ap	aplite / pegmatite granitic gneiss	Precambrian
gn	granitic gneiss, w/localized schist inclusions	Precambrian

Wall rock alteration

- epidote
- sericite
- chlorite
- argillic
- silicification
- potash feldspar
- biotite

- iron oxide staining after sulfides
- pyritic halo, dashed where inferred
- iron oxide stained fracture trends (after sulfides)
- 23 | 24, 26 | 25 — 26 · 25: section corner and quarter corner
- rock contact, dashed where inferred, dotted where concealed or unknown

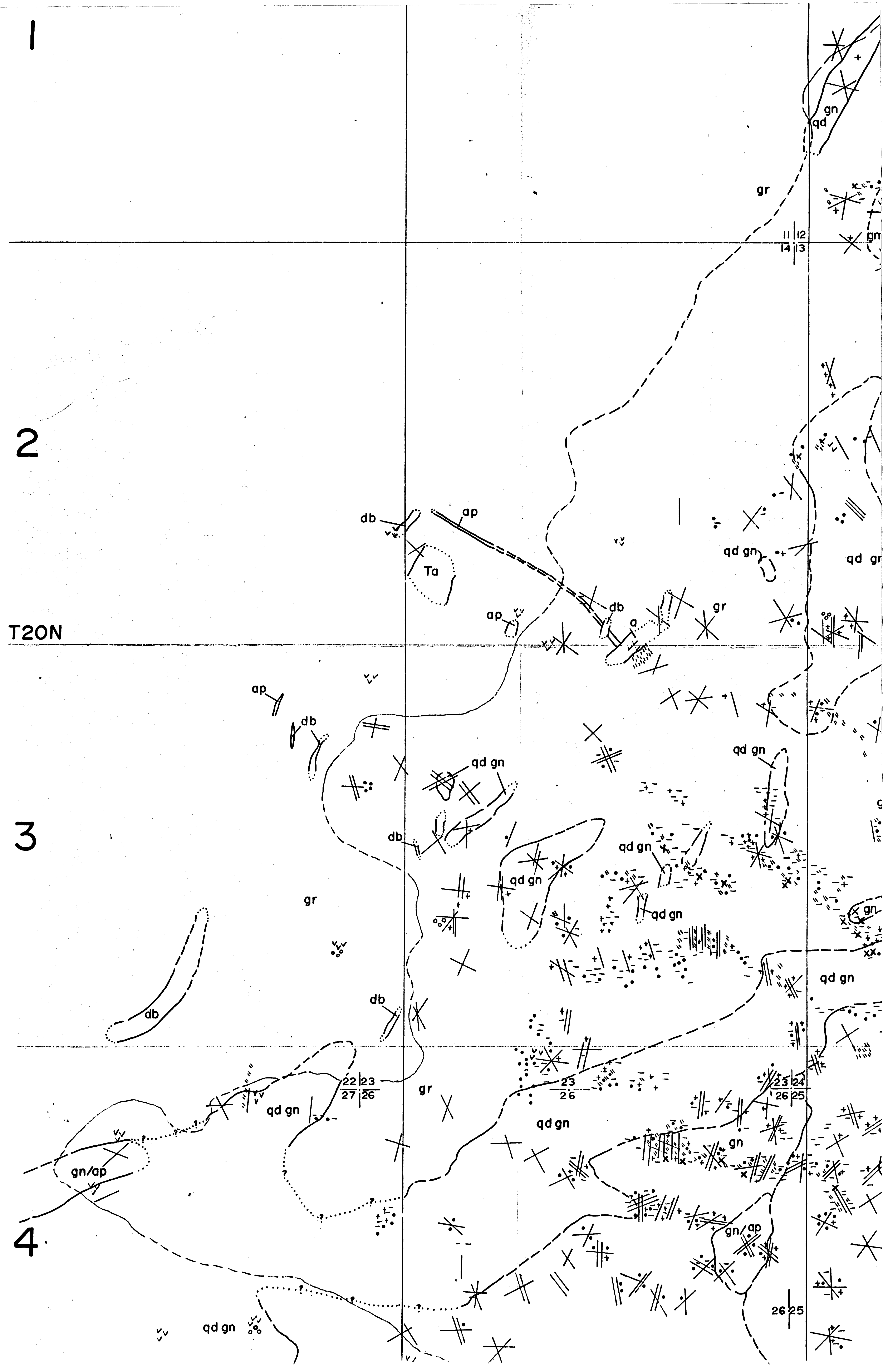
FIGURE 7

Wheeler Wash Area, Mohave County, Arizona

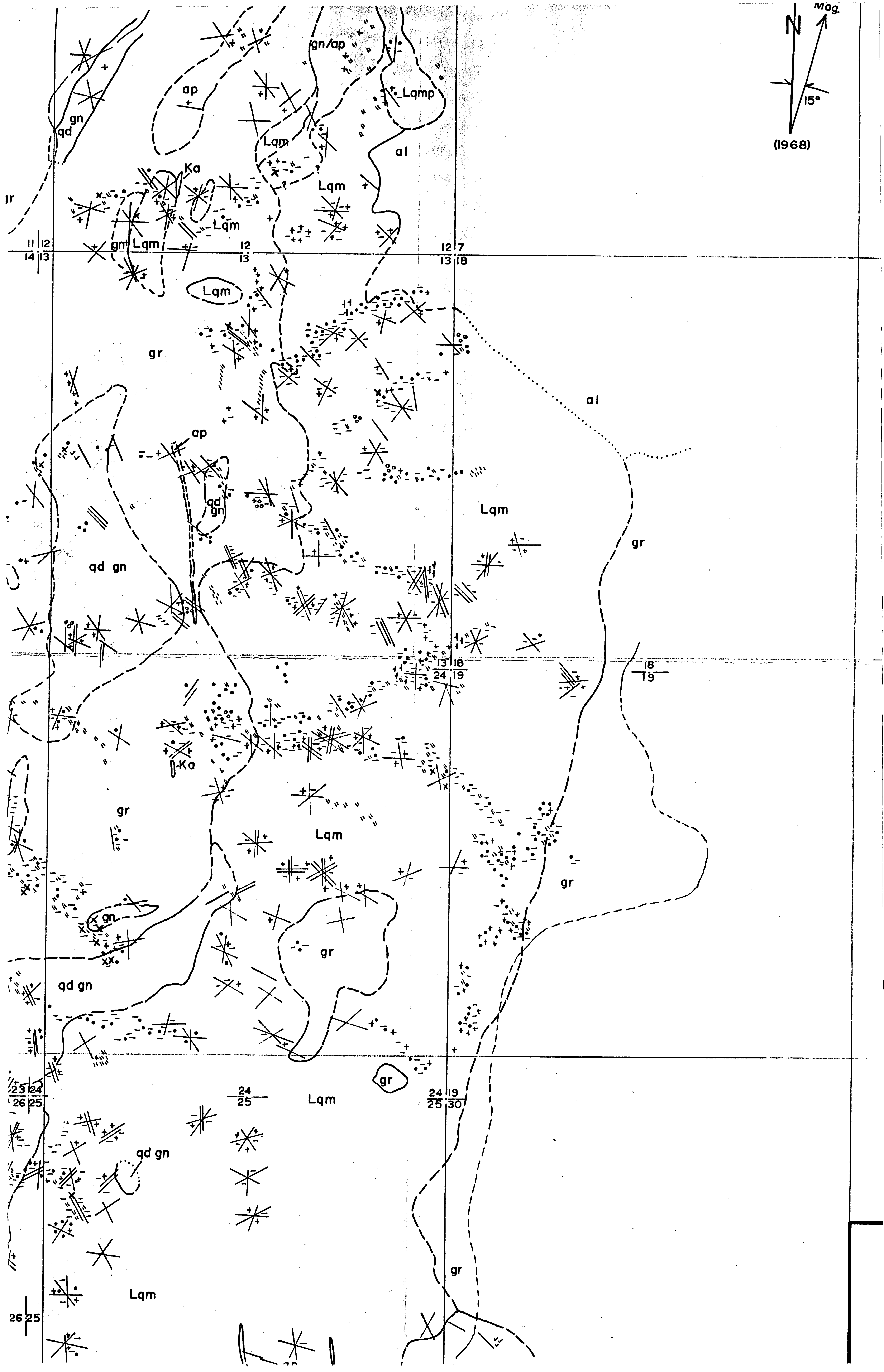
ALTERATION MAP

John S. Vuich

0 500 1000 2000 3000



1
2
3
4
T20N
gr
gn
qd
11 | 12
14 | 13
qd gn
db
ap
Ta
a
22 | 23
27 | 26
23
26
23 | 24
26 | 25
26 | 25
gn/ap



N
Mag.
15°
(1968)
gn/ap
Lqmp
ap
gn
qd
Ka
Lqm
al
gr
11 12
14 13
12
13
12 7
13 18
gd
gn
qd gn
13 18
24 19
18
19
x gn
23 24
26 25
24
25
24 19
25 30
26 25

(8:4115

CONFIDENTIAL

MINERALIZED AREAS

IN THE

WARM SPRINGS SE QUADRANGLE

MOHAVE COUNTY, ARIZONA

by

Joseph E. Worthington
Balbach Minerals Inc.
5825 N. Camino del Conde
Tucson, Arizona 85718

May 8, 1981

A brief program of follow-up was undertaken in February on some geological targets identified last year. The program was based on an hypothesis outlined in a memo dated December 30, 1980 describing last year's work. The geologic hypothesis, briefly, is that the time of mineralization at the Oatman district has been identified in the volcanic stratigraphy of the Black Mountains and can be traced southward in the range. Airborne reconnaissance last year identified several possible target areas for mineralization at the proposed stratigraphic horizon which were reviewed in the field in February.

The most striking altered zone observed from the air is the silica quarry about five miles north of the Franconia siding on the Santa Fe Railroad (Figure 1). The altered area includes the silica quarry itself (Figure 2) described in the previous memo and at least one adjacent peak comprised in part of altered volcanics (Figure 3). The altered zone contains at least two and maybe more rhyolitic intrusives into a foliated granitic rock that resembles the Precambrian Katherine Granite. The rhyolitic units may be plugs or stratified units of limited areal extent and they appear to be capped with a zone of intense silicified tuff (as seen in Figure 3) that may be 100 feet thick. Alternately the silicification may occur in a brecciated plug as at the silica quarry (Figure 2). In both cases the mineralization is capped by unmineralized welded tuffs and basalt.

Two more areas of silicified units, that were noted as whitish color anomalies, overlain by unmineralized volcanics were examined to the north of the silica quarry. The first is about three miles to the north in the NW¼ Section 23, T 17 N, R 19 W and the second is about three miles northwest of the first in the SW¼ Section 9, T 17 N, R 19 W (Figure 1). Other similar alteration was observed to the north and northeast but was not visited. Two photographs of the first altered

Figure 2

Silica Quarry, looking east from access road

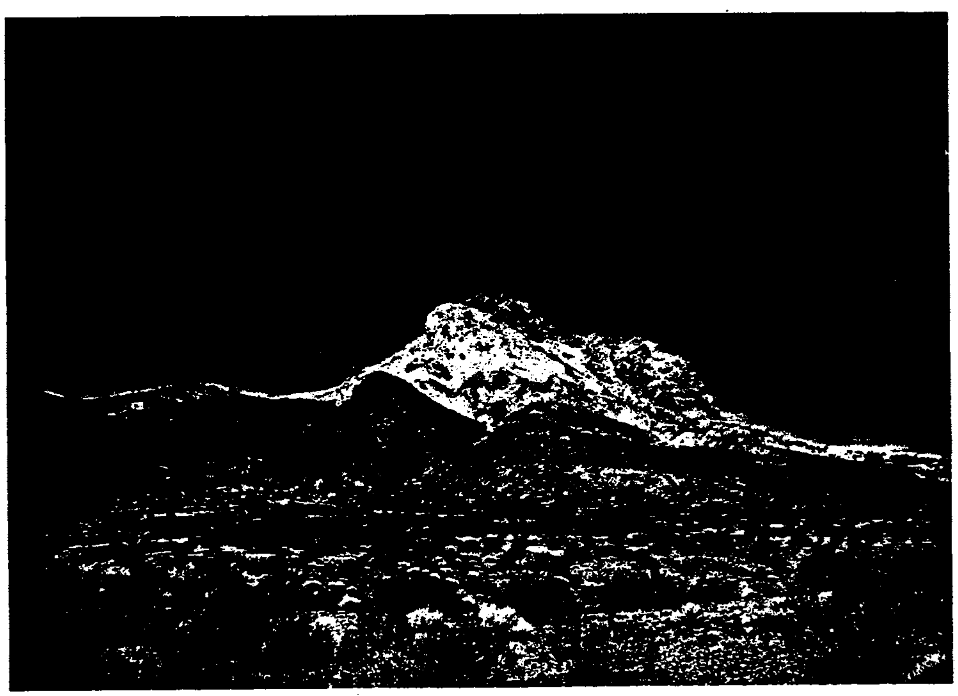


Figure 3

Altered Volcanics capped by unaltered basalt,
looking west from access road

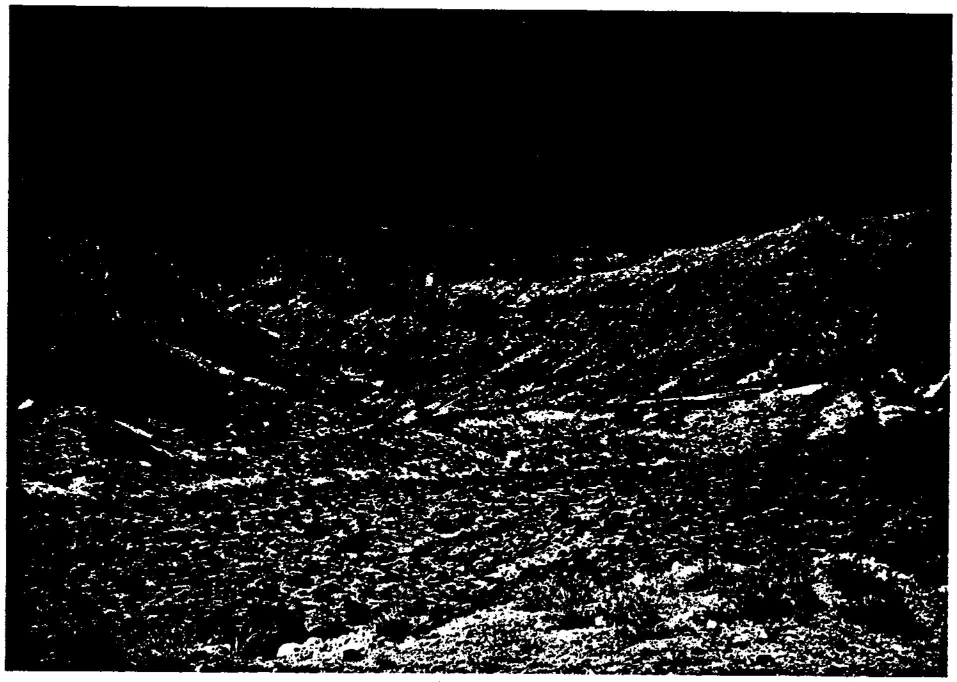


Figure 4

Silicified Volcanics across center of photo
capped by unmineralized volcanics,
looking north from drillsite on road

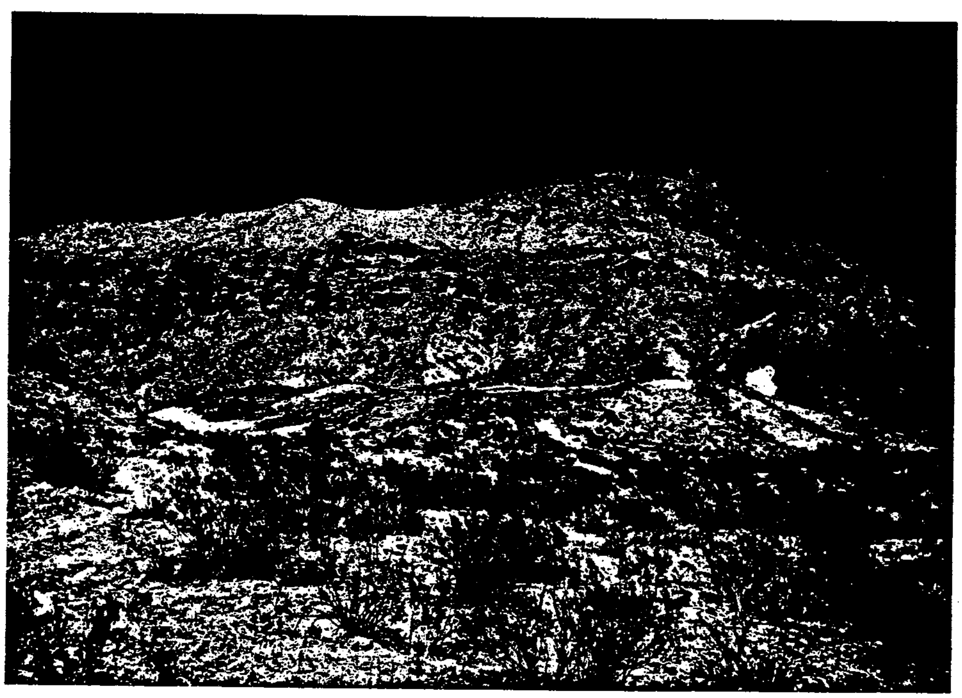


Figure 5

Same zone as Figure 4 from southwest end,
looking northeast

area (Section 23) are included as Figures 4 and 5 that well illustrate the silicified outcrop area overlain by unmineralized volcanics.

Reconnaissance sampling of the altered areas was not particularly encouraging. More consistent values in arsenic rather than molybdenum do, however, suggest an epithermal precious metal system of the Oatman type, rather than a molybdenum porphyry system. No significant precious metal anomalies were detected. The large size of the area of interest, however, is still permissive of one or several precious-metal deposits being present. I believe, therefore, that more detailed geologic mapping to better define the possible mineralized horizon and considerable more sampling would be warranted on a low priority basis, perhaps next winter. The potential still would be detection of hidden precious metal mineralization, very likely of the type found in the Katherine Granite at the Tyro Mine, or high-grade veins in more competent volcanic strata.

TUCSON OFFICE

ROCKY MOUNTAIN GEOCHEMICAL CORP.

2561 EAST FORT LOWELL ROAD · TUCSON, ARIZONA 85716 · PHONE: (602) 795-9780

Certificate of Analysis

RMGC Numbers:

Local Job No.: 81-3-31T

Foreign Job No.:

Invoice No.: T10307

Date: March 30, 1981

Client: Continental Materials
P.O. Box 50726
Tucson, Arizona 85703

Client Order No.:

Report On: 46 samples

Submitted by: H.T. Eyrich

Date Received: March 2, 1981

Analysis: Cu, Pb, Zn, As, Au, Ag & Mo

Analytical Methods: As determined by Colorimetry.
All others by Atomic Absorption.

Remarks:

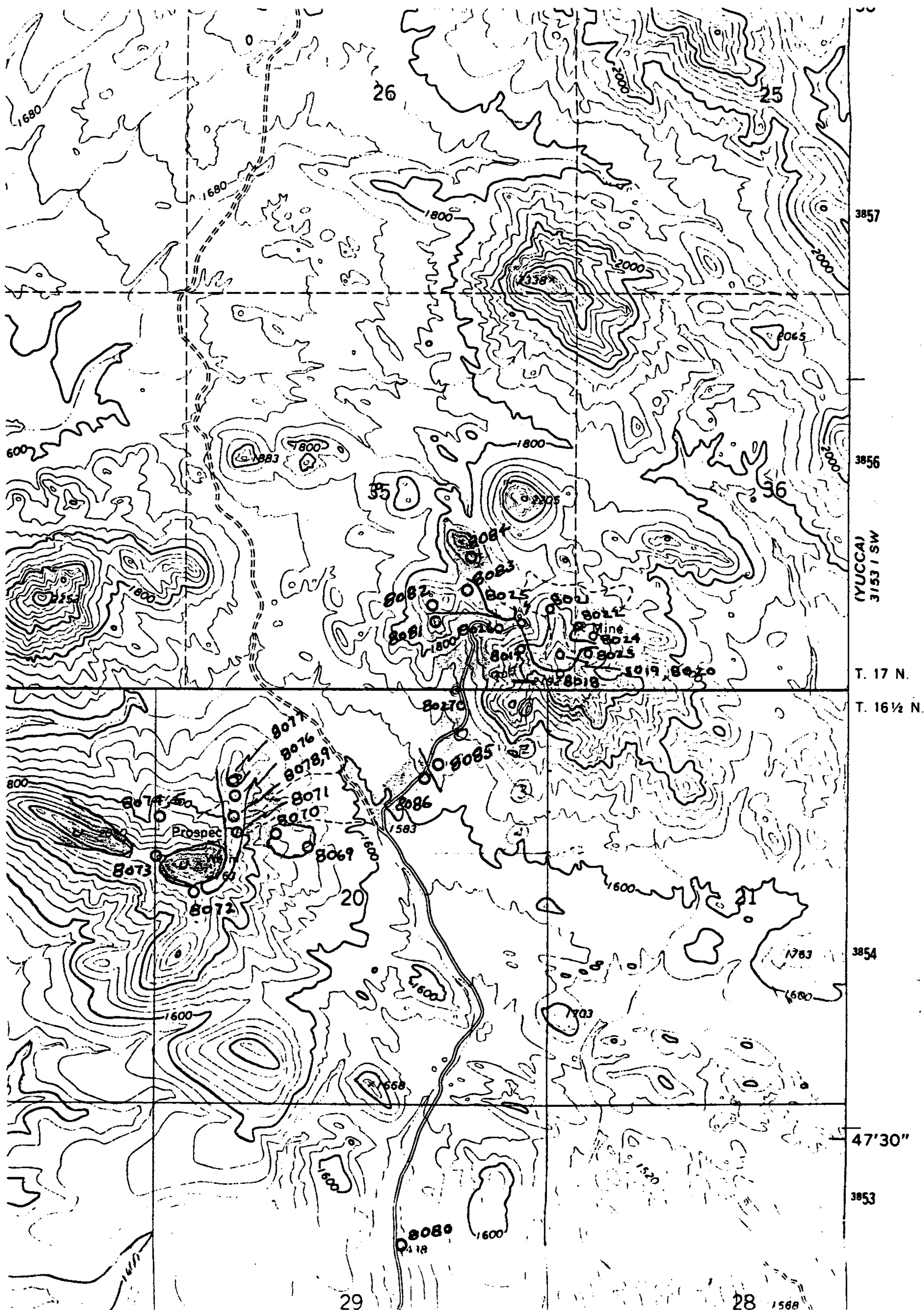
cc: Enc: 1
J.E. Worthington, 5825 Camino del Conde, Tucson, AZ. 85718
RMGC/SLC
file

SJA/lr

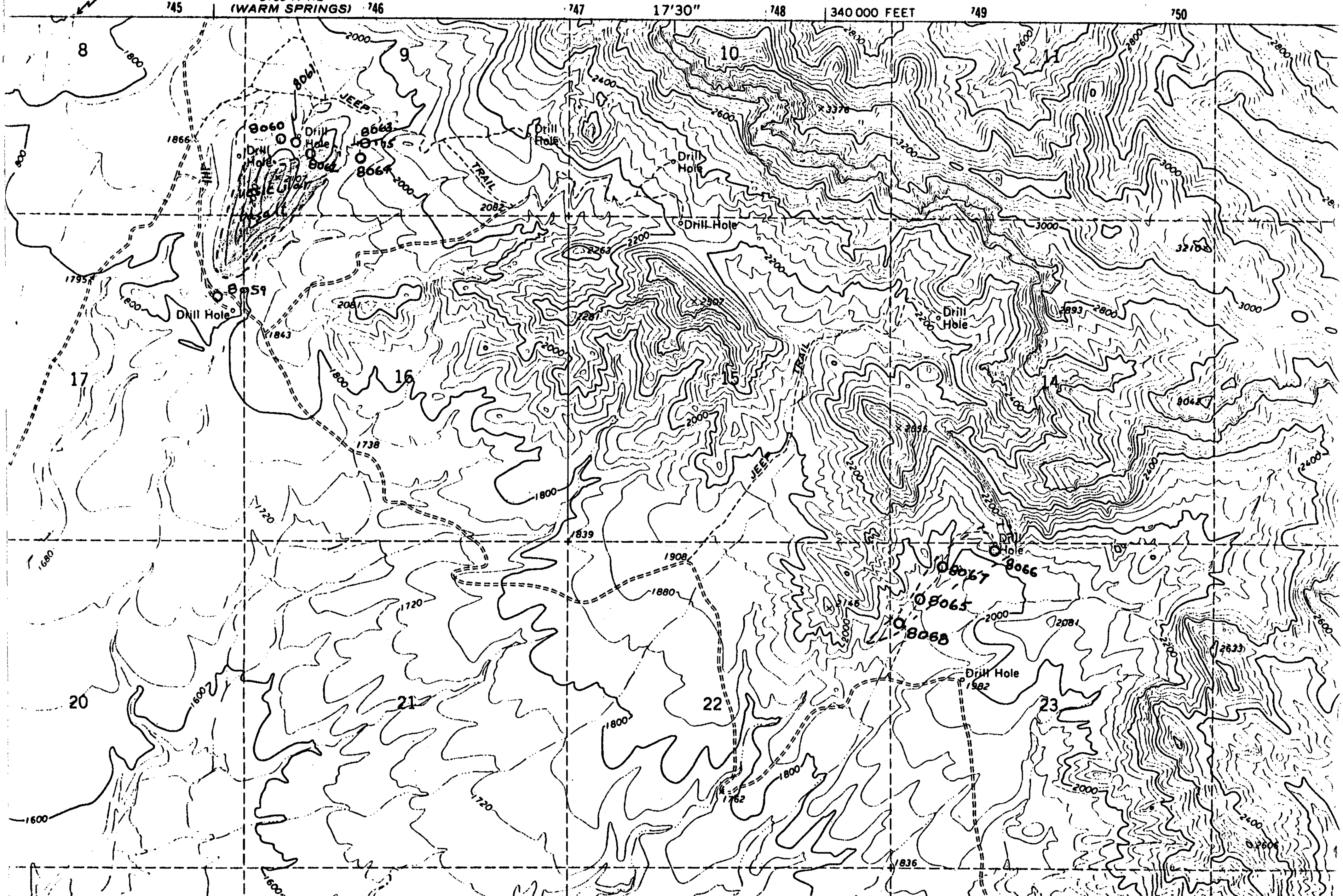
ND = None Detected   1 ppm = 0.0001%   1 Troy oz./ton = 34.286 ppm   1 ppm = 0.0292 Troy oz./ton

Client Continental Materials Date March 30, 1981 RMGC Job No. 81-3-31T

Sample Number	Mo ppm	As ppm	Au ppm	Ag ppm
8059	1	21	-0.1	-1
8060	6	160	0.5	1
61	3	6	-0.1	-1
62	6	40	-0.1	-1
63	2	15	-0.1	-1
64	-1	7	-0.1	-1
65	3	5	-0.1	-1
66	3	11	-0.1	-1
67	8	2	-0.1	-1
68	5	90	-0.1	-1
69	3	15	-0.1	-1
8070	4	10	-0.1	-1
71	-1	4	-0.1	-1
72	2	9	-0.1	-1
73	-1	-5	-0.1	-1
74	1	3	-0.1	-1
75	8	4	-0.1	-1
76	4	15	-0.1	-1
77	2	9	-0.1	-1
78	4	27	-0.1	-1
79	3	28	-0.1	-1
8080	2	5	-0.1	-1
81	5	5	-0.1	-1
82	3	12	-0.1	-1
8083	2	9	-0.1	-1
8084	6	5	-0.1	-1
85	58	19	-0.1	-1
86	4	18	-0.1	-1


26
25
35
36
20
21
29
28
1680
1800
2000
2065
1883
2205
1600
1583
1703
1763
1668
8084
8083
8082
8081
8025
8021
8022
Mine
8024
8023
8019
8020
8018
8027
8085
8086
8077
8076
8078,9
8071
8070
8069
8074
8073
8072
8080
Prospect
T. 17 N.
T. 16½ N.
(YUCCA)
3153 I SW
3857
3856
3854
3853
47'30"

WARM SPRINGS SE QUA
ARIZONA–MOHAVE C
7.5 MINUTE SERIES (TOPOC



CONFIDENTIAL

PRECIOUS METAL RECONNAISSANCE IN MOHAVE COUNTY ARIZONA

by

Joseph E. Worthington
Balbach Minerals, Inc.
Tucson, Arizona

December 30, 1980

INTRODUCTION

A program of reconnaissance for precious metal deposits in Mohave County, Arizona was begun in November 1980. The program included seven days in the field based in Kingman. Mohave County was selected because of the presence of the major Oatman gold district in Tertiary volcanic rocks. (Figure 1). The intent of the program is to locate another such concentration of precious metals, probably related to Tertiary volcanic activity.

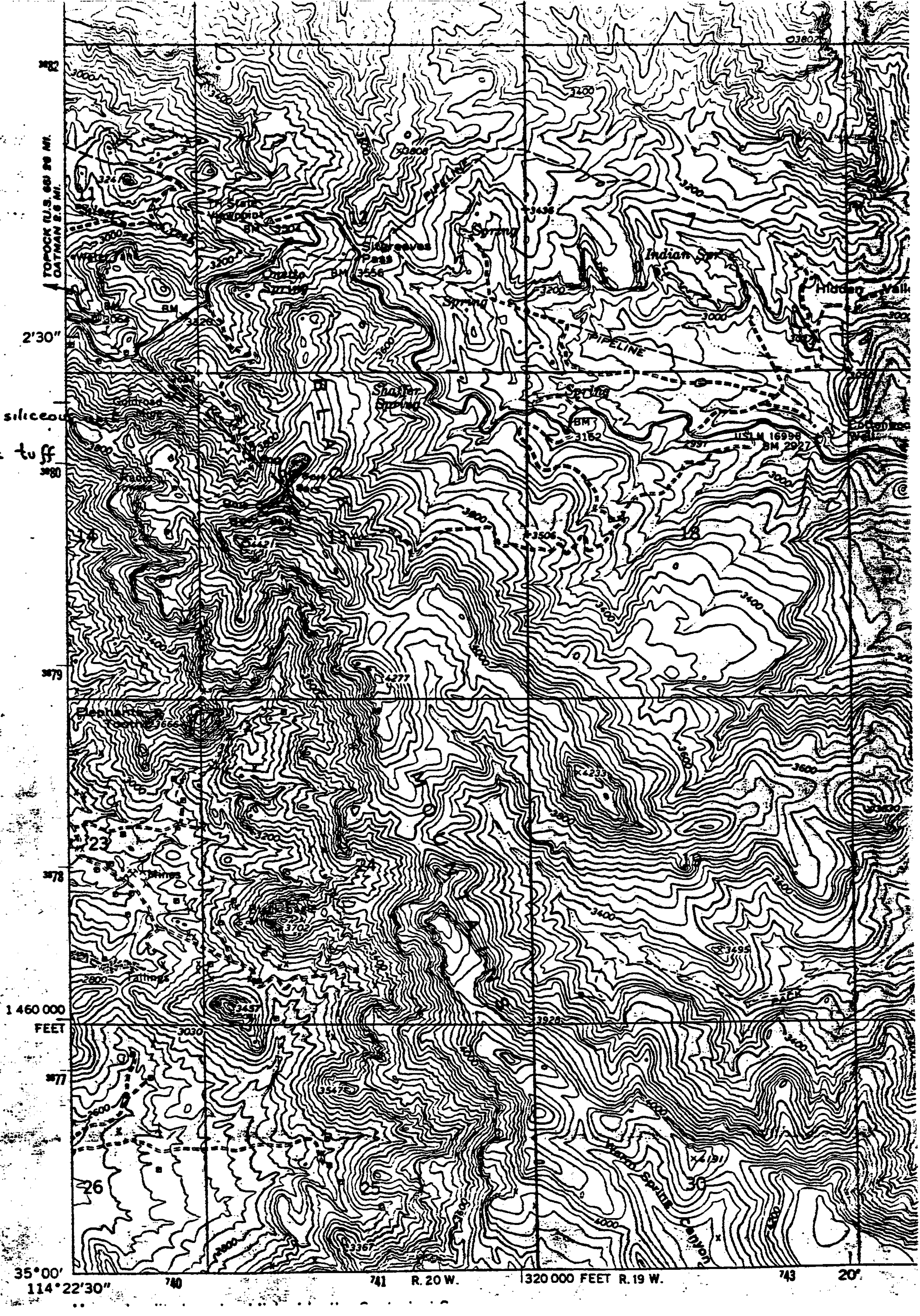
RATIONALE FOR PROGRAM (based on Oatman)

The premise on which the program is based is that understanding of geologic relationships and control of mineralization at Oatman may allow prediction of other environments with potential for significant concentrations of precious metals. Mineralization at Oatman occurs primarily as high-grade ore shoots in multi-staged quartz veins primarily in the Oatman andesite. The Oatman consists of thick, massive flows that sustain fractures well; and is therefore a very favorable host for large vein systems. Vein mineralization is also found in the next two overlying volcanic units, the Gold Road latite and the Antelope quartz latite. Specifically the Gold Road vein can be traced south-easterly from its outcrop on the paved highway through successively higher units as far as into the Antelope. The southeast trace of the Gold Road vein was therefore examined in the field in order to gain a better perspective of the mineralization at Oatman.

The Gold Road Vein in the Oatman District

A brief examination of the southeast trace of the Gold Road vein confirmed the relationships noted above (Figure 2). The Gold Road vein can be traced as a strong quartz-filled fracture southeasterly

basalt
upper siliceous
argillic tuff



into the outcrop area of the Antelope quartz latite. Wallrock alteration generally consists of argillic alteration in the volcanics with widths of a few feet to a few tens of feet around the vein. The Antelope is a multiple unit consisting of rhyolite tuffs (that may be inter-fingering lenses of the Sitgreaves tuff) and thin, glassy porphyritic flows. The uppermost flow unit is prominently silicified in the vicinity of the Gold Road vein, but neither the vein nor the alteration persists into the overlying basalt. The mineralization is therefore related in time and almost certainly in origin to the final event of Antelope volcanism. Sampling of the upper siliceous unit does not suggest that gold mineralization is widespread away from the vein (8011, 8013, 8014, 8015), but the geologic relationships, nevertheless, strongly suggest that the quartz-vein mineralization is the conduit system for a surficial siliceous hot springs system at the close of Antelope time. Other precious metal mineralization should then be sought associated with felsic intrusives or surficial deposits near the middle of the Tertiary volcanic section, but not stratigraphically above them. Mineralization could occur as surficial exhalite deposits (although it is doubtful that they will be preserved in a continental environment) or as veins or fracture zones in the felsic volcanics or any underlying rock. If directly underlying strata are massive flows as in the Oatman district, then strong vein systems as at Oatman are to be expected. If underlying rocks are the Precambrian Katherine granite, which is more prone to develop wide fracture zones, then a wide zone of disseminated ore may occur, as at the Tyro mine.

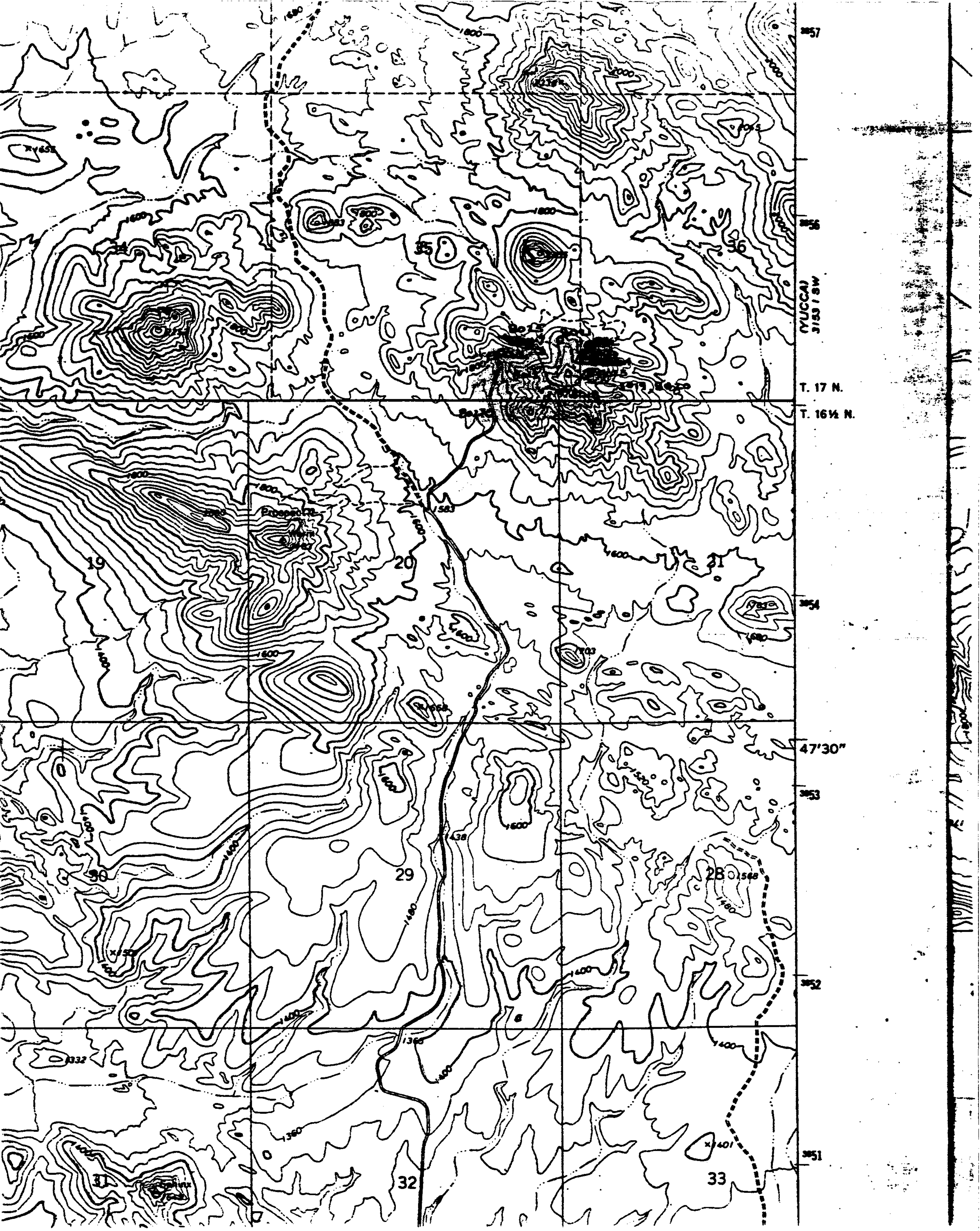
PROSPECTIVE AREAS IN MOHAVE COUNTY

Initially, it was decided to restrict the reconnaissance to the Black Range, from I-40 northwest to the areas withdrawn from mineral entry near the Colorado River. The Black Range is composed of nearly flat-lying sequences of Tertiary volcanics overlying Precambrian basement. The intent of the program is to identify strata-bound mineralized areas and underlying altered roots. The presence of the known mineralization at Oatman and other areas in the Black Range were the initial justification for the program. One of the first phases was an aerial reconnaissance by light plane of most of the accessible parts of the range. This reconnaissance enabled elimination of large areas and selection of targets and areas for more detailed examination.

Franconia Silica

The Franconia silica mine is a prominent white scar near the south end of the range. An attempt was apparently made to ship silica in recent years, but there is no current activity at the property. The Franconia silica mine is about 5 miles north of the Franconia exit on I-40.

The Franconia silica occurs as a brecciated mass of solid silica associated with at least two rhyolite porphyries intruding Precambrian gneiss. There also appear to be other nearby areas of porphyry outcrop that were not examined. Geologic realtions suggest a series of silica-rich intrusives culminating in the solid silica mass that could indicate an underlying mineralized porphyry system. Geochemical sampling (Figure 3 and assays) is not particularly encouraging, but the area is geologically interesting enough to warrant more prospecting. It is significant that the mineralization is associated with rhyolitic intrusives and is overlain by unmineralized tuff (immediately west of the silica mine). The mineralization appears therefore to be related to a rhyolitic volcanic unit, as with other mineralization in the Black Range. Land status in the area of the Franconia silica mine is summarized in Figure 4.



3857
3856
(YUCCA)
3153 I SW
T. 17 N.
T. 16½ N.
3854
47'30"
3853
3852
3851
34
35
36
19
20
21
30
29
28
31
32
33
Prospect
1600
1800
2000
1400
1360
1583
1568
1401
1332

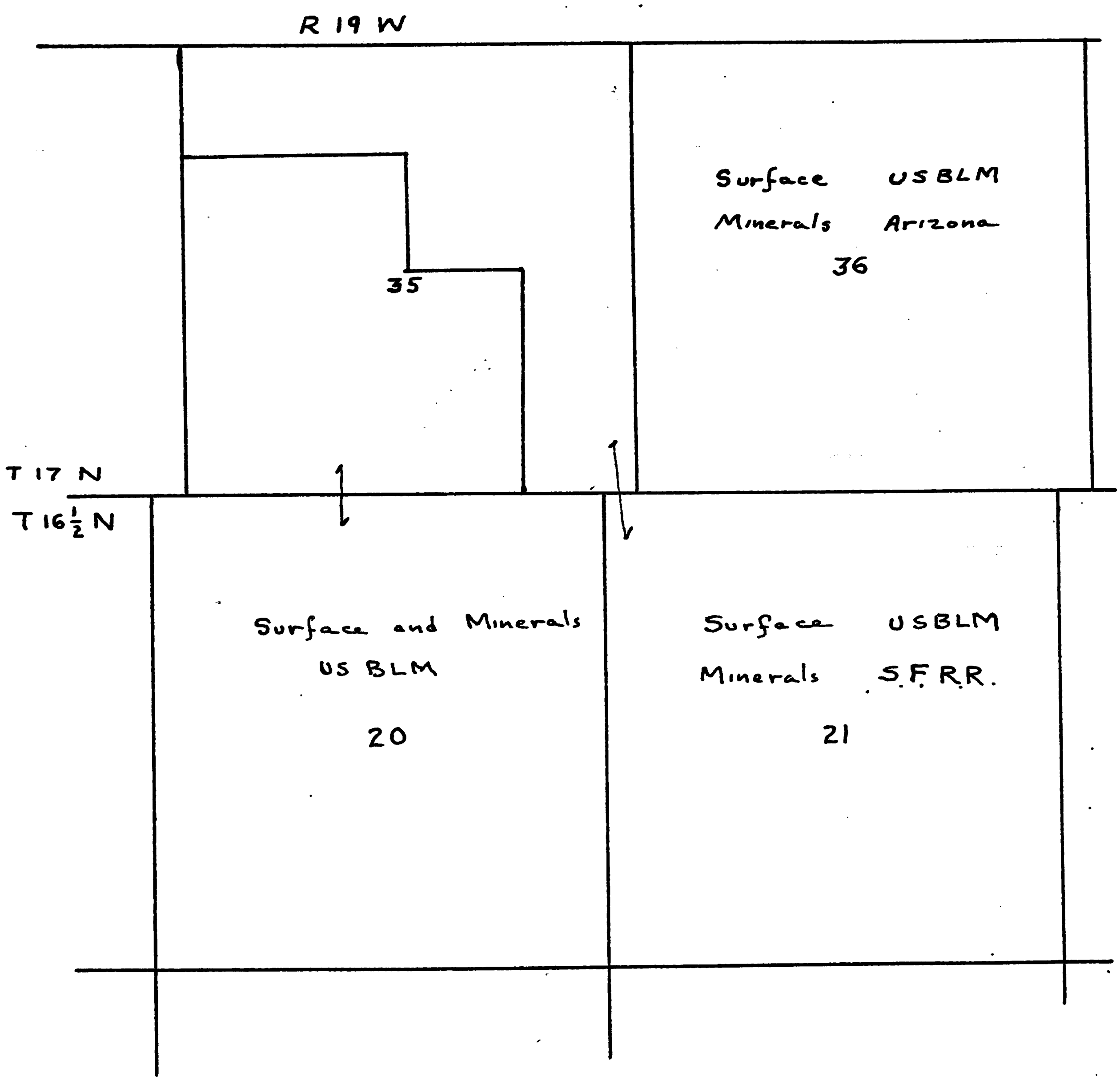


Figure 4

Land Status
Franconia Silica
Mohave Co Arizona
1" = 2000'

JEW Dec 1980

Volcanic Neck at Gem Acres

A group of prospects immediately north of the Gem Acres exit on I-40 was briefly examined. No obvious mineralization was noted (Figure 5 and assays) but the area is suspected of being a center of explosive rhyolite volcanism. Prominent rhyolitic breccias containing fragments of volcanic glass are noted that suggest the area may actually be a volcanic conduit.

Secret Pass Area

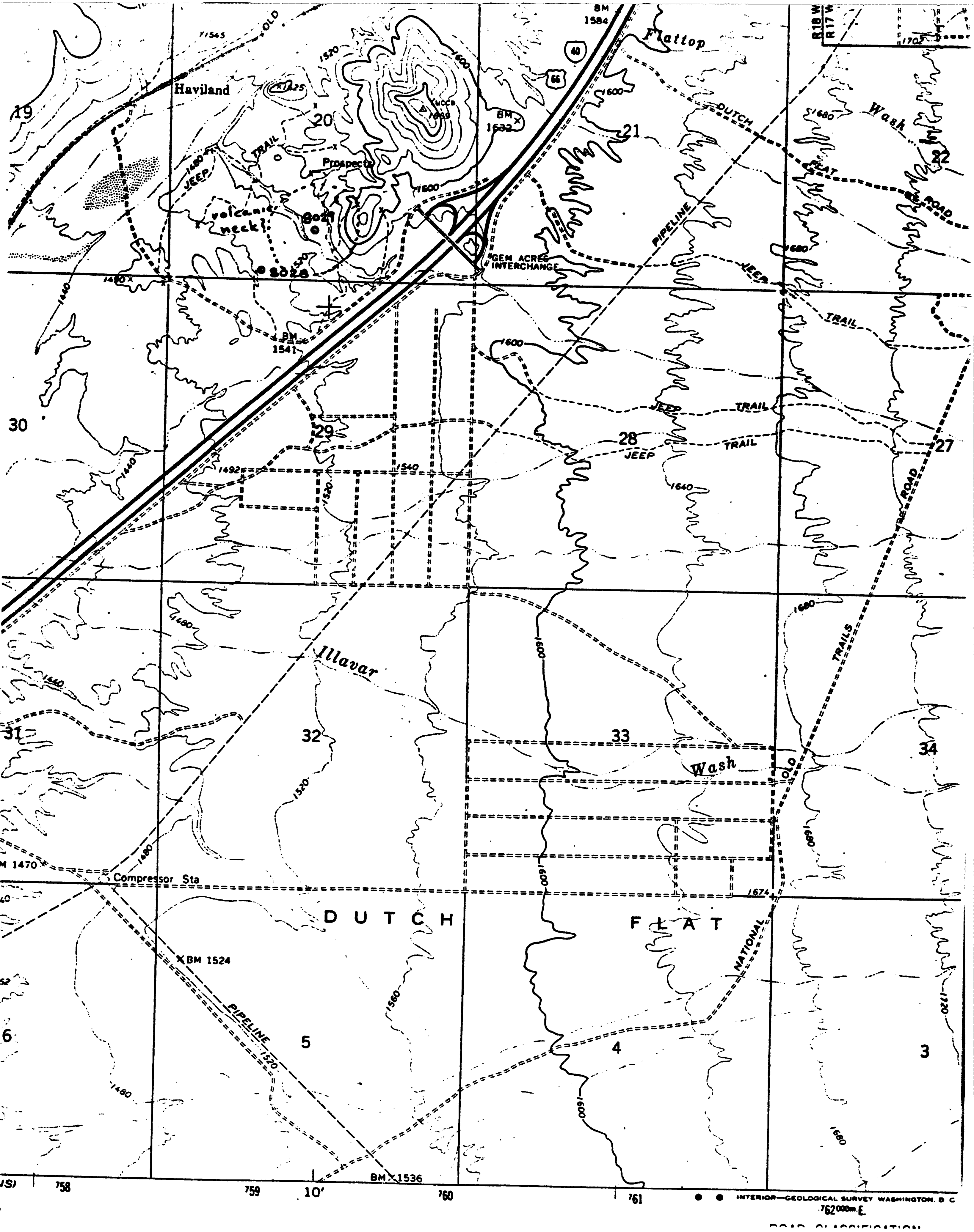
A small group of prospects in the Secret Pass area was also briefly examined and sampled (Figure 6 and assays). Mineralization occurs associated with rhyolite dikes in Precambrian gneiss. Two samples were collected containing in excess of 2 ppm Au. Each only represented a narrow structure, but in the absence of more comprehensive sampling they must be regarded as moderately encouraging.

Tyro Mine

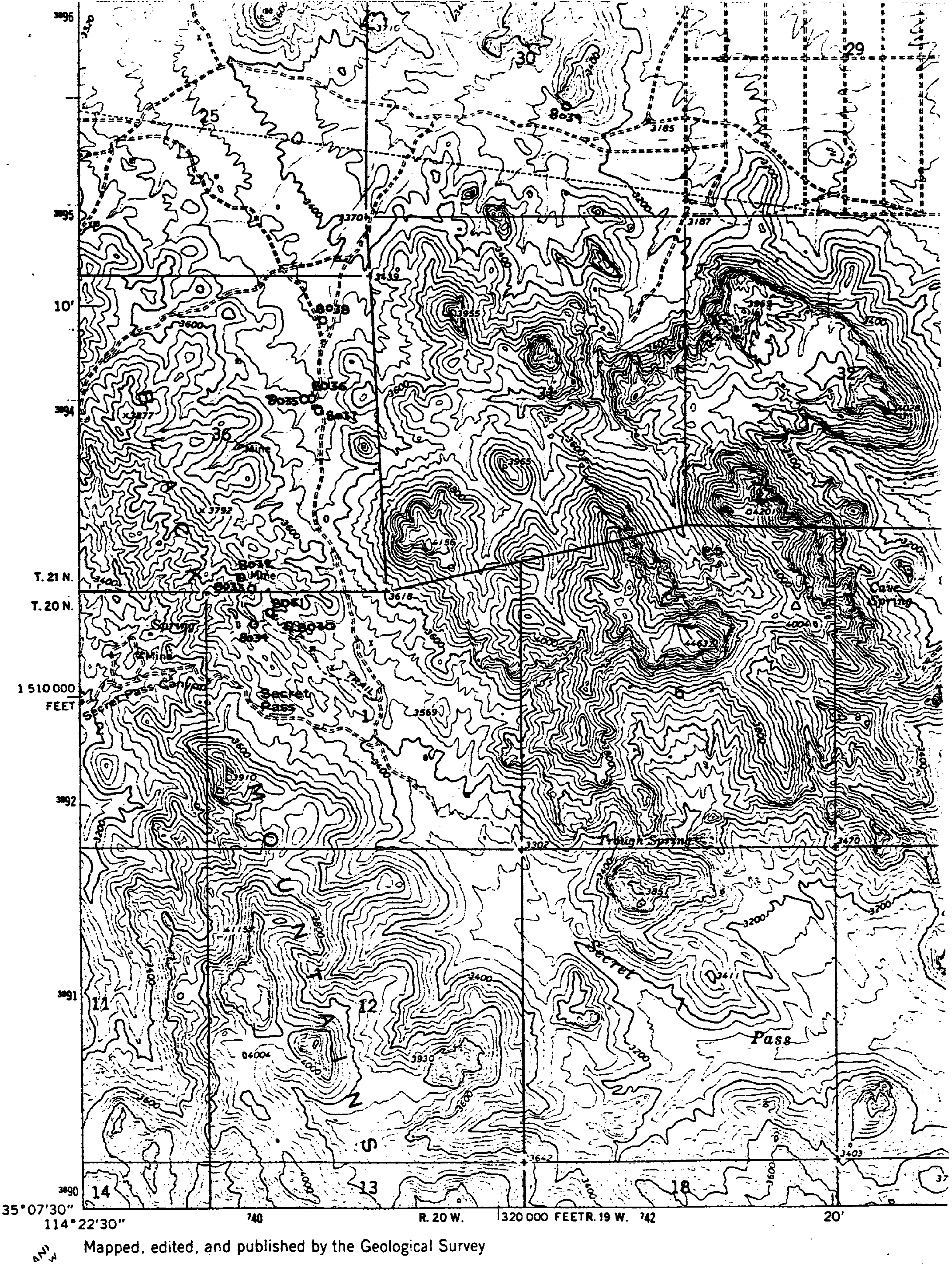
The Tyro mine is a zone of mineralization and alteration from 50 to 100 feet in width and several thousand feet in length. Portions grade in the range 0.05 to over 0.1 oz. gold per ton. The prospect is currently being developed by Las Vegas promotional interests. Freeport Minerals has staked several hundred claims in the area and was also drilling near Union Pass in November 1980.

Cottonwood Pass Area

The Cottonwood Pass Road is the only road through the Black Range in the area immediately north of Kingman. A large area containing many prospects and prominent yellow-white rhyolite



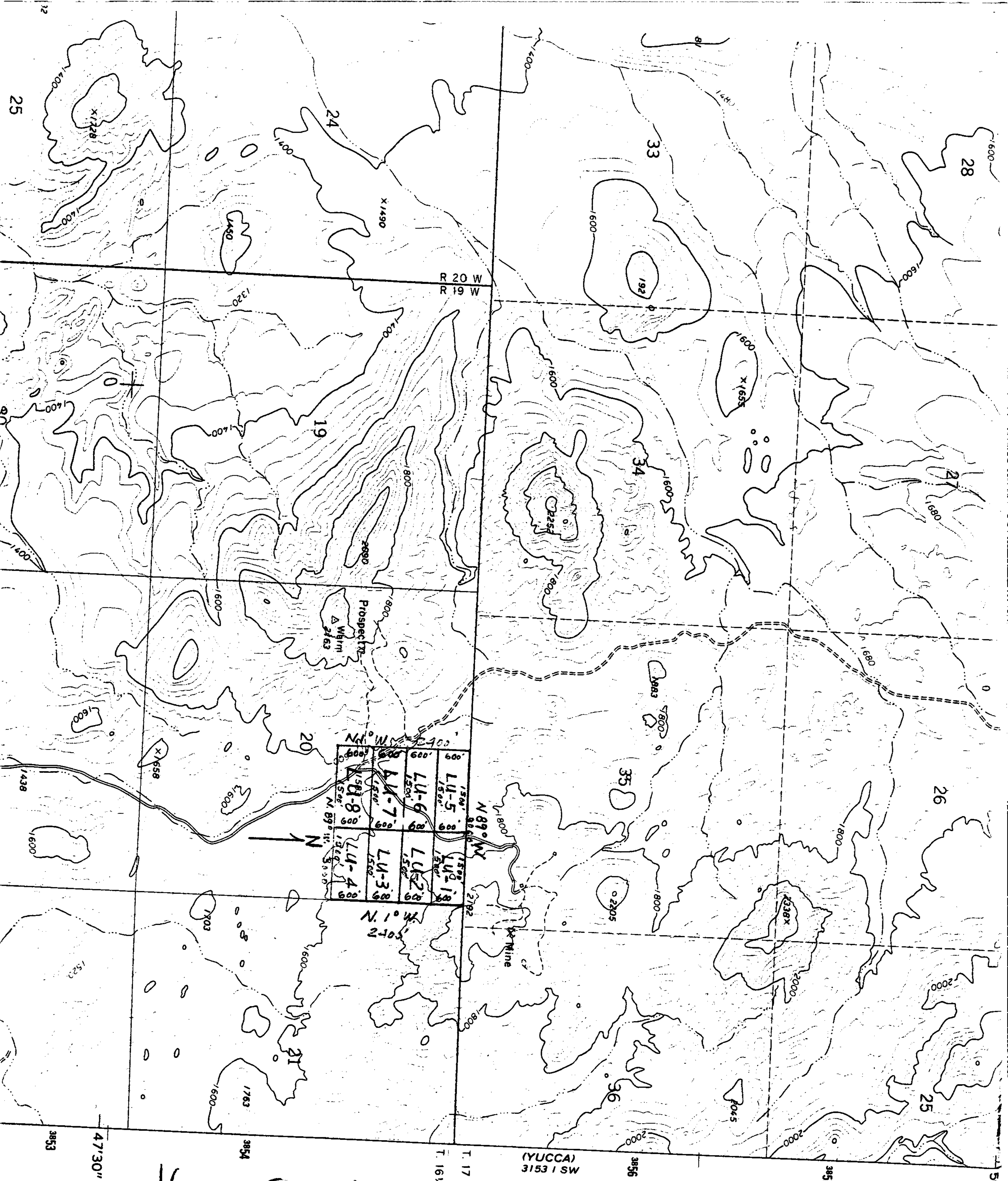
Haviland
Flattop
Yucca
Prospects
volcanic neck?
GEM ACRES INTERCHANGE
DUTCH FLAT ROAD
Dutch Wash
JEEP TRAIL
PIPELINE
Illavar Wash
OLD NATIONAL TRAILS ROAD
Compressor Sta
DUTCH FLAT
BM 1584
BM 1632
BM 1541
BM 1524
BM 1536
19
20
21
22
27
28
29
30
31
32
33
34
3
4
5
6
758
759
10'
760
761
762000m.E.
R18W
R17W
INTERIOR—GEOLOGICAL SURVEY WASHINGTON, D C



Mapped, edited, and published by the Geological Survey exposures was selected during the airborne reconnaissance. Occidental Minerals has a large claim group in the area, so no follow up was undertaken.

CONCLUSIONS AND RECOMMENDATIONS

No obvious new areas of gold mineralization were defined during the week's field work. It does appear that the premise on which the program was based has validity, as many gold prospects appear to be related to rhyolite intrusives that are somewhere in the middle of the Tertiary sequence. Continued reconnaissance, particularly near the Franconia silica mine and in the Secret Pass area, appears to be warranted. An additional one to two weeks prospecting and sampling in these and possibly other areas in the Black Range should therefore be undertaken early in 1981.



Henry Engvich claims —

TUCSON OFFICE

ROCKY MOUNTAIN GEOCHEMICAL CORP.

2561 EAST FORT LOWELL ROAD · TUCSON, ARIZONA 85716 · PHONE: (602) 795-9780

Certificate of Analysis

RMGC Numbers:
Local Job No.: 80-55-19T
Foreign Job No.:
Invoice No.: T10104

Date: December 17, 1980

Client: Continental Materials
2002 N. Forbes Blvd.
Suite 101
Tucson, Arizona 85705

Client Order No.:

Report On: 30 samples

Submitted by: H.T. Eyrich

Date Received: November 25, 1980

Analysis: Mo, Au, Ag & As

Analytical Methods: Mo, Au & Ag determined by Atomic Absorption.
As determined by Colorimetry.

Remarks: F & SiO_2 to be reported from Salt Lake City.

cc: J.E. Worthington, 5825 N. Camino del Conde, Tucson, AZ.
RMGC/SLC
file

SJA/lr

Sample Number	Mo ppm	As ppm	Au ppm	Ag ppm
8010	3	6	-0.1	-1
11	2	3	-0.1	-1
12			-0.1	-1
13			-0.1	-1
14	2	3	-0.1	-1
15	2	3	-0.1	-1
8016	-1	6	-0.1	-1

ND = None Detected 1 ppm = 0.0001% 1 Troy oz./ton = 34.286 ppm 1 ppm = 0.0292 Troy oz./ton

Client Continental Materials Date December 17, 1980 RMGC Job No. 80-55-19T

Sample Number	Mo ppm	As ppm	Au ppm	Ag ppm
8017	3	3	-0.1	-1
18	4	9	-0.1	-1
19	2	9	-0.1	-1
8020	3	3	-0.1	-1
21	4	3	-0.1	-1
22	1	-1	-0.1	-1
23	2	6	-0.1	-1
24	3	12	-0.1	-1
25	3	43	-0.1	-1
26	2	6	-0.1	-1
27	2	9	-0.1	-1
28	1	5	-0.1	-1
29	2	-1	-0.1	-1
8030	35	9	-0.1	-1
31			2.4	1
32			-0.1	-1
33			-0.1	-1
34			2.3	3
35			-0.1	-1
36			0.1	-1
37	5	9	0.5	-1
38	2	40	-0.1	-1
8039	2	12	-0.1	-1

By Shirley J. Aiken

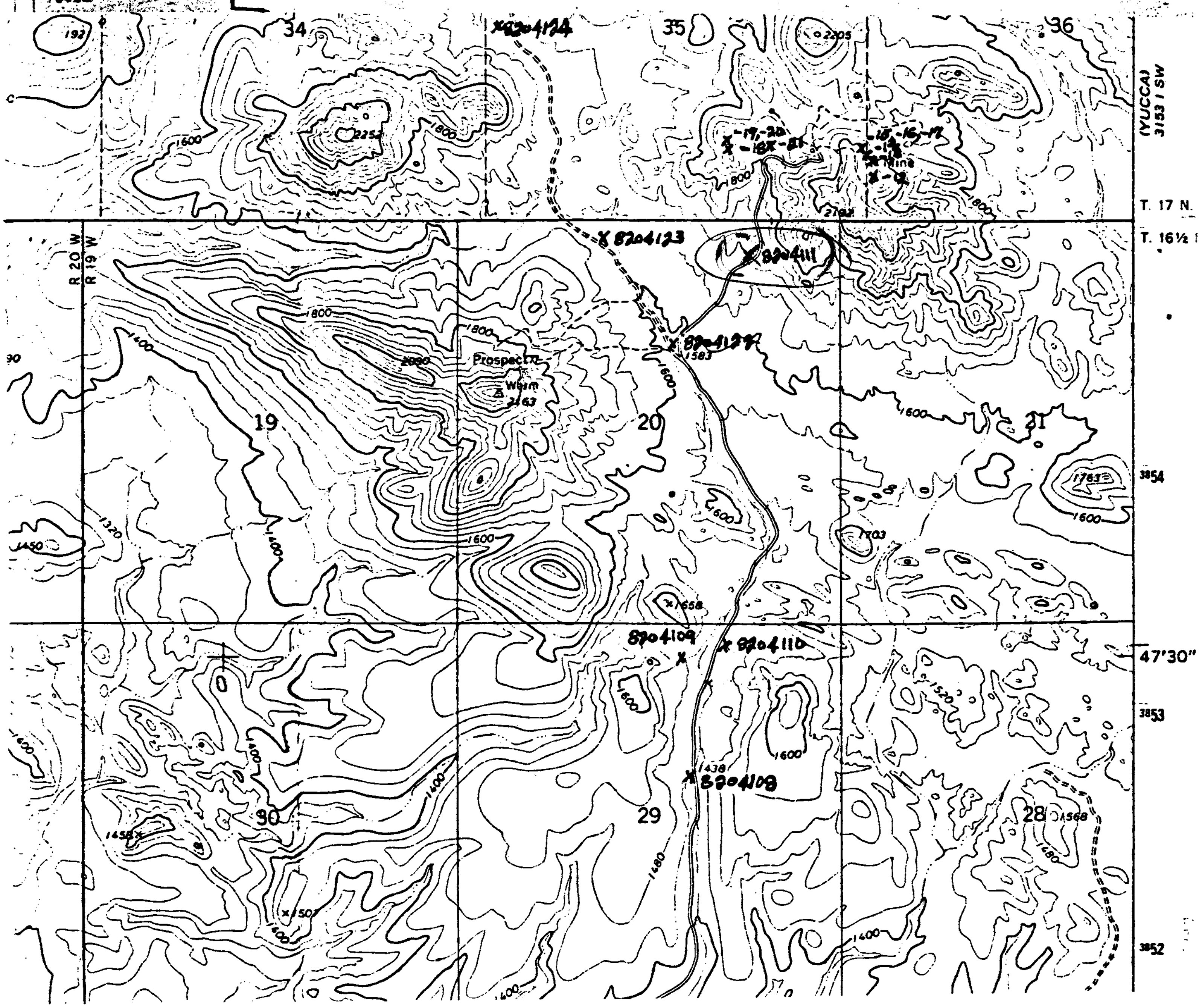
Shirley J. Aiken

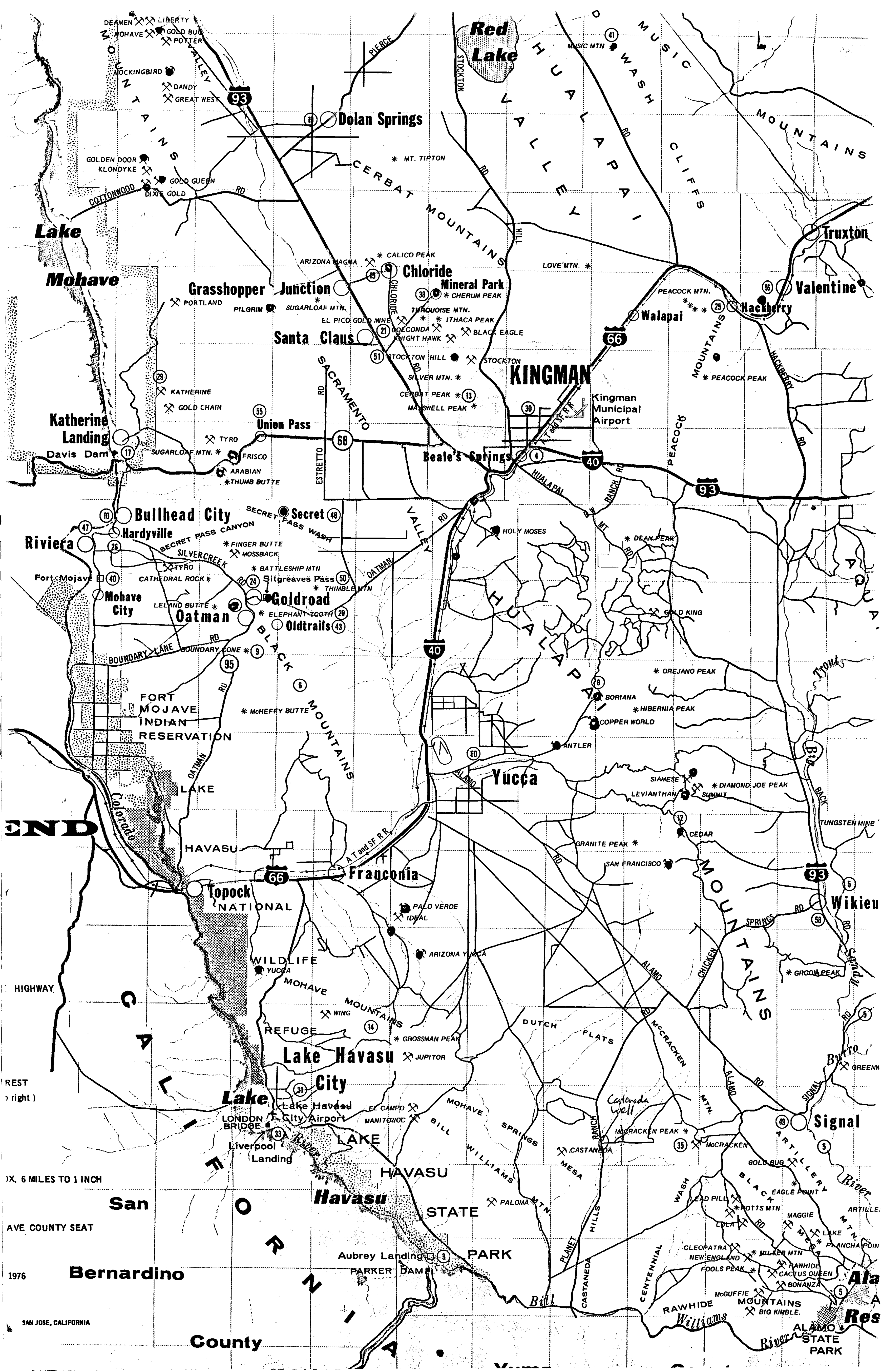
ROCKY MOUNTAIN GEOCHEMICAL CORP.
SALT LAKE CITY, UTAH • RENO, NEVADA • TUCSON, ARIZONA

1983 Sampling

REC#/	SAMPLE NUMBER /T/S	AG/J1 PPM	W/T2 PPM		AU/T1 PPB	AS/D2 PPM	HG/J1 PPB		SB/ 9 PPM	OW/00 LBS.	SW/00 LBS.	L G
0001	8204108 S	0.2	4		5	48	425		7	12.00	9.50	3
0002	8204109 S	0.2	6	T	25	25	145		5	13.50	4.00	
0003	8204110 S	0.2	10		10	24	300		4	16.25	8.75	1
0004	8204111 S	0.2	103		3160	33	500		16	16.00	6.00	1
0005	8204122 S	0.2	45		5	42	750	L	2	12.75	9.25	4
0006	8204123 S	0.2	23		15	21	2150	L	2	11.50	5.50	[illegible]
0007	8204124 S	0.2	8	L	5	10	210		8	11.50	6.25	7
0008	8204125 S	0.2	6		10	21	230	L	2	14.50	8.25	6
0009	8204126 S	0.2	5	L	5	8	1250	L	2	15.00	9.00	12
0010	8204127 S	0.2	5	L	5	23	3600	L	2	12.25	8.00	[illegible]
0011	8204128 S	0.2	20	T	25	22	1900	L	2	14.25	4.25	[illegible]
0012	8204129 S	0.2	6		5	12	500	L	2	14.75	6.50	[illegible]
0013	8204130 S	0.2	5	R	10	12	255	L	2	16.50	3.50	
0014	8204131 S	0.2	4	L	5	9	450	L	2	14.00	5.25	
0015	8204132 S	0.2	3	L	5	26	425	L	2	12.25	7.00	
0016	8204133 S	0.2	5	L	5	26	1000	L	2	15.50	5.25	

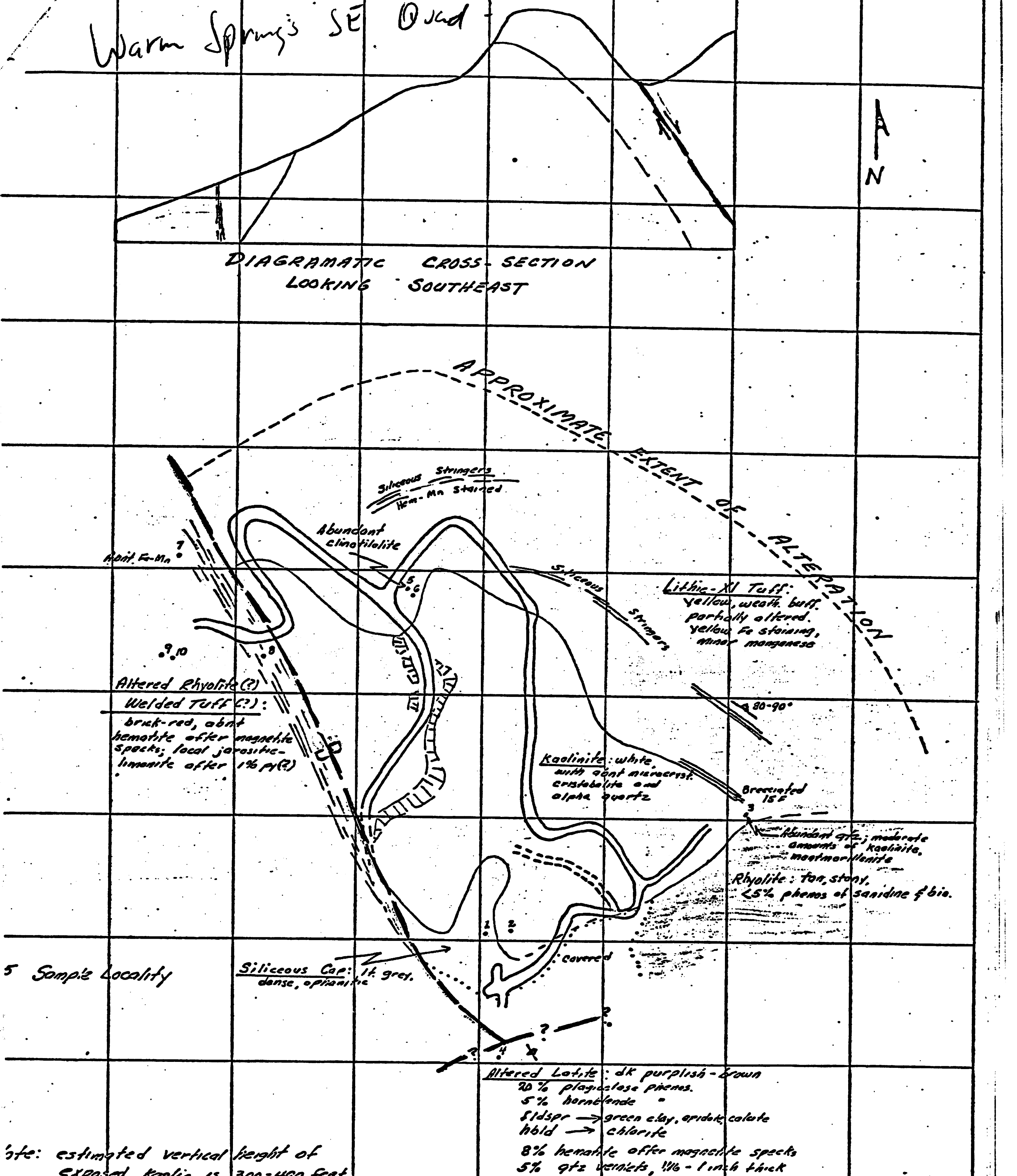
7½ Quad
Warm Springs
SE, Ariz.





Red Lake
HUALAPAI VALLEY
MUSIC MTN
MUSIC MOUNTAINS
WASH RD
CLIFFS
STOCKTON
PIERCE
DEAMEN
LIBERTY
MOHAVE
GOLD BUG
POTTER
MOCKINGBIRD
DANDY
GREAT WEST
MOUNTAINS
VALLEY
93
Dolan Springs
MT. TIPTON
CERBAT MOUNTAINS
GOLDEN DOOR
KLONDYKE
GOLD QUEEN
DIXIE GOLD
COTTONWOOD RD
Lake Mohave
HILL
Truxton
ARIZONA MAGMA
CALICO PEAK
LOVE MTN.
Chloride
CHLORIDE
Mineral Park
CHERUM PEAK
Grasshopper Junction
PORTLAND
PILGRIM
SUGARLOAF MTN.
PEACOCK MTN.
Hackberry
Valentine
Walapai
TURQUOISE MTN.
ITHACA PEAK
EL PICO GOLD MINE
GOLCONDA
BLACK EAGLE
KNIGHT HAWK
Santa Claus
STOCKTON HILL
STOCKTON
66
KINGMAN
SACRAMENTO RD
SILVER MTN.
CERBAT PEAK
MAXWELL PEAK
PEACOCK PEAK
KATHERINE
GOLD CHAIN
Kingman Municipal Airport
A T and SF R R
Katherine Landing
Davis Dam
Union Pass
68
ESTRETTO
TYRO
SUGARLOAF MTN.
FRISCO
ARABIAN
THUMB BUTTE
Beale's Springs
40
HUALAPAI
RANCH RD
PEACOCK
HACKBERRY RD
Bullhead City
Secret
SECRET PASS WASH
Hardyville
SECRET PASS CANYON
Riviera
FINGER BUTTE
MOSSBACK
SILVERCREEK
TYRO
BATTLESHIP MTN
VALLEY RD
HOLY MOSES
DEAN PEAK
MT RD
Fort Mojave
CATHEDRAL ROCK
Sitgreaves Pass
THIMBLE MTN
OATMAN
Mohave City
LELAND BUTTE
Goldroad
Oatman
ELEPHANT TOOTH
Oldtrails
HUALAPAI
GOLD KING
AQUA
BOUNDARY LANE
BOUNDARY CONE
RD
BLACK MOUNTAINS
95
FORT MOJAVE INDIAN RESERVATION
McHEFFY BUTTE
OREJANO PEAK
BORIANA
HIBERNIA PEAK
COPPER WORLD
ANTLER
Trout
Big
BACK
OATMAN
LAKE
Yucca
ALAMO
SIAMESE
DIAMOND JOE PEAK
LEVIANTHAN
SUMMIT
CEDAR
TUNGSTEN MINE
END
Colorado
HAVASU
GRANITE PEAK
SAN FRANCISCO
Franconia
MOUNTAINS
Topock
NATIONAL
PALO VERDE
IDEAL
Wikieup
SPRINGS RD
WILDLIFE
ARIZONA YUCCA
YUCCA
HIGHWAY
CHICKEN
GROOM PEAK
MOHAVE MOUNTAINS
WING
REFUGE
GROSSMAN PEAK
DUTCH FLATS
McCRACKEN
Sandy
Lake Havasu City
JUPITOR
Burro
GREENW
REST
right
Lake Havasu City Airport
LONDON BRIDGE
EL CAMPO
MANITOWOC
MOHAVE
BILL WILLIAMS
SPRINGS MESA
Casteneda Well
RANCH
ALAMO RD
SIGNAL
MTN.
Signal
LAKE
Liverpool Landing
River
McCRACKEN PEAK
CASTANEDA
McCRACKEN
ARTILLERY
GOLD BUG
River
6 MILES TO 1 INCH
HAVASU
WASH
LEAD PILL
EAGLE POINT
POTTS MTN
BLACK
ARTILLE
San
Havasu
STATE
PALOMA
MTN
HILLS
MAGGIE
LOLA
LAKE
MESA
ARIZONA COUNTY SEAT
CALIFORNIA
CENTENNIAL
CLEOPATRA
MILLER MTN
PLANCHA POIN
NEW ENGLAND
RAWHIDE
PLANET
Aubrey Landing
PARK
FOOLS PEAK
CACTUS QUEEN
1976
Bernardino
PARKER DAM
CASTANEDA
BONANZA
Bill
McGUFFIE
MOUNTAINS
RAWHIDE
BIG KIMBLE
Williams
SAN JOSE, CALIFORNIA
ALAMO STATE PARK
River
County

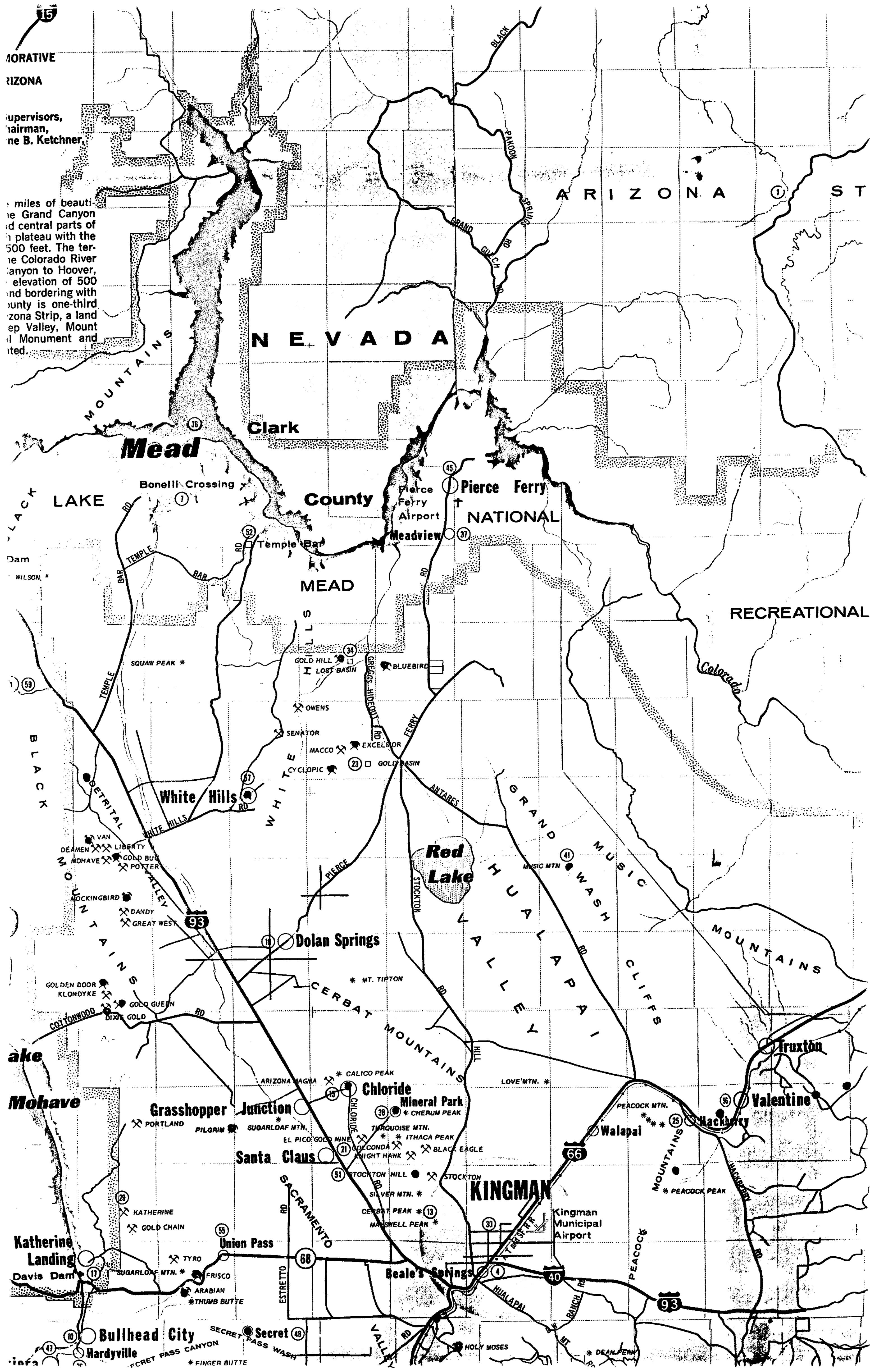
Warm Springs SE Quad



NE MOTUS CHEMICAL Co. LOCATION E½ SE¼ SEC. 35, T17N, R19W LEVEL

OLOGY BY E.S. MONTGOMERY SURVEY MOHAVE CO. STATE ARIZONA SCALE 1" = 200 FT.

BRUNTON-PACE E RECONNAISSANCE MAP EL. 1-17-72


15
IORATIVE
IZONA
upervisors,
airman,
ne B. Ketchner,
miles of beauti-
e Grand Canyon
d central parts of
plateau with the
500 feet. The ter-
e Colorado River
anyon to Hoover,
elevation of 500
nd bordering with
unty is one-third
zona Strip, a land
ep Valley, Mount
l Monument and
ted.
BLACK
PAKOON SPRINGS
GRAND GULCH RD
ARIZONA
ST
NEVADA
MOUNTAINS
Clark
County
Mead
LAKE
Bonelli Crossing
Temple Bar
TEMPLE BAR RD
Dam
WILSON
Pierce Ferry Airport
Pierce Ferry
NATIONAL
Meadview
MEAD
RECREATIONAL
Colorado
SQUAW PEAK
GOLD HILL
LOST BASIN
BLUEBIRD
GREGGS HIDEOUT RD
OWENS
SENATOR
MACCO
EXCELSIOR
CYCLOPIC
GOLD BASIN
FERRY
ANTARES
WHITE HILLS
White Hills
DETRITAL VALLEY
BLACK MOUNTAINS
VAN
DEAMEN
LIBERTY
MOHAVE
GOLD BUG
POTTER
MOCKINGBIRD
DANDY
GREAT WEST
GRAND WASH CLIFFS
MUSIC MOUNTAINS
MUSIC MTN
Red Lake
STOCKTON
HUALAPAI VALLEY
PIERCE
Dolan Springs
MT. TIPTON
CERBAT MOUNTAINS
GOLDEN DOOR
KLONDYKE
GOLD QUEEN
DIXIE GOLD
COTTONWOOD RD
Lake Mohave
ARIZONA MAGMA
CALICO PEAK
Chloride
Mineral Park
CHERUM PEAK
LOVE MTN.
Truxton
Valentine
Hackberry
PEACOCK MTN.
Walapai
PEACOCK MOUNTAINS
PEACOCK PEAK
Grasshopper
Junction
PORTLAND
PILGRIM
SUGARLOAF MTN.
TURQUOISE MTN.
ITHACA PEAK
EL PICO GOLD MINE
GOLCONDA
BLACK EAGLE
NIGHT HAWK
Santa Claus
STOCKTON HILL
STOCKTON
SILVER MTN.
SACRAMENTO
CERBAT PEAK
MAXWELL PEAK
KINGMAN
Kingman Municipal Airport
KATHERINE
GOLD CHAIN
Katherine Landing
Davis Dam
TYRO
Union Pass
SUGARLOAF MTN.
FRISCO
ARABIAN
THUMB BUTTE
ESTRETTO
Beale's Springs
HUALAPAI
Bullhead City
Hardyville
Secret
SECRET PASS WASH
SECRET PASS CANYON
FINGER BUTTE
HOLY MOSES
DEAN PEAK
RANCH RD
PEACOCK
HACKBERRY RD
HILL
66
40
93
68

USGS PP 1015

PROCEEDINGS OF
THE FIRST ANNUAL WILLIAM T. PECORA MEMORIAL SYMPOSIUM,
OCTOBER 1975, SIOUX FALLS, SOUTH DAKOTA

An Application of Satellite Imagery to Mineral Exploration

By Mark A. Liggett and John F. Childs,
Cyprus Georesearch Company,
Los Angeles, California 90071

ABSTRACT

The application of satellite remote-sensing techniques to mineral exploration is based on the ability to recognize a variety of geologic features characteristically associated with hydrothermal alteration and related mineralization. Such features can include favorable structural settings, lithologic associations, and alteration color or topographic anomalies. Successful application of satellite imagery, however, is dependent upon the size and expression of these characteristic features and their predictive value for narrowing the area of exploration to a practical size for economical evaluation using other exploration techniques. Landsat–1 MSS imagery has been effectively used in studying the regional tectonic controls of Cenozoic volcanism, plutonism, and related gold, silver, and base metal mineralization in part of the Basin and Range province of southern Nevada, eastern California, and northwestern Arizona. Within a volcanogenic province aligned along the Colorado River south of Lake Mead, Nevada, the locations of known mineral deposits appear in satellite imagery to be spatially associated with generally east-west structural trends, transverse to the north-south structural grain typical of the province. Field reconnaissance in this area has confirmed a temporal as well as spatial relationship between mineralization and the anomalous east-west structural trends. Assuming a genetic relationship between structure and mineralization, systematic analysis of Landsat imagery and subsidiary data has provided a basis for selecting new targets for ground-based exploration reconnaissance.

INTRODUCTION

Applications of satellite remote-sensing techniques to mineral exploration have generally been based on the ability to observe characteristics of mineralization, associated alteration or other related features in synoptic imagery of relatively low resolution. Such characteristic features can include alteration color and topographic anomalies, distinctive lithologic associations, favorable structural settings, and vegetation changes caused by soil geochemical anomalies. The relative value of these features as exploration guides often varies with the genetic type of mineralization, geologic terrane, and climatic setting. The economic advantages of using satellite imagery depend both on the success of detecting these features and the costs of obtaining comparable information using alternate methods.

In the western United States, direct surface expressions of alteration and mineralization are likely to have been recognized long ago by conventional means. In such well-explored areas, it is necessary that the exploration methods used lead to the detection of blind or poorly exposed mineralization. One approach to reconnaissance exploration for such ore deposits is the selection of preliminary targets on the basis of favorable structural settings or other regional geologic associations.

This paper summarizes a study in which Landsat–1 imagery was used in studying the regional structural settings of known gold, silver, and base metal deposits in part of the Basin and Range province of southern Nevada, eastern California, northwestern Arizona and southwestern Utah as shown in figure 1. The synoptic overview of regional geology and the identification of specific structural features expressed in the Landsat–1 imagery has led to the development of a regional model for the tectonic control of Cenozoic volcanism, plutonism, and genetically related epithermal mineralization within a portion of the study area.

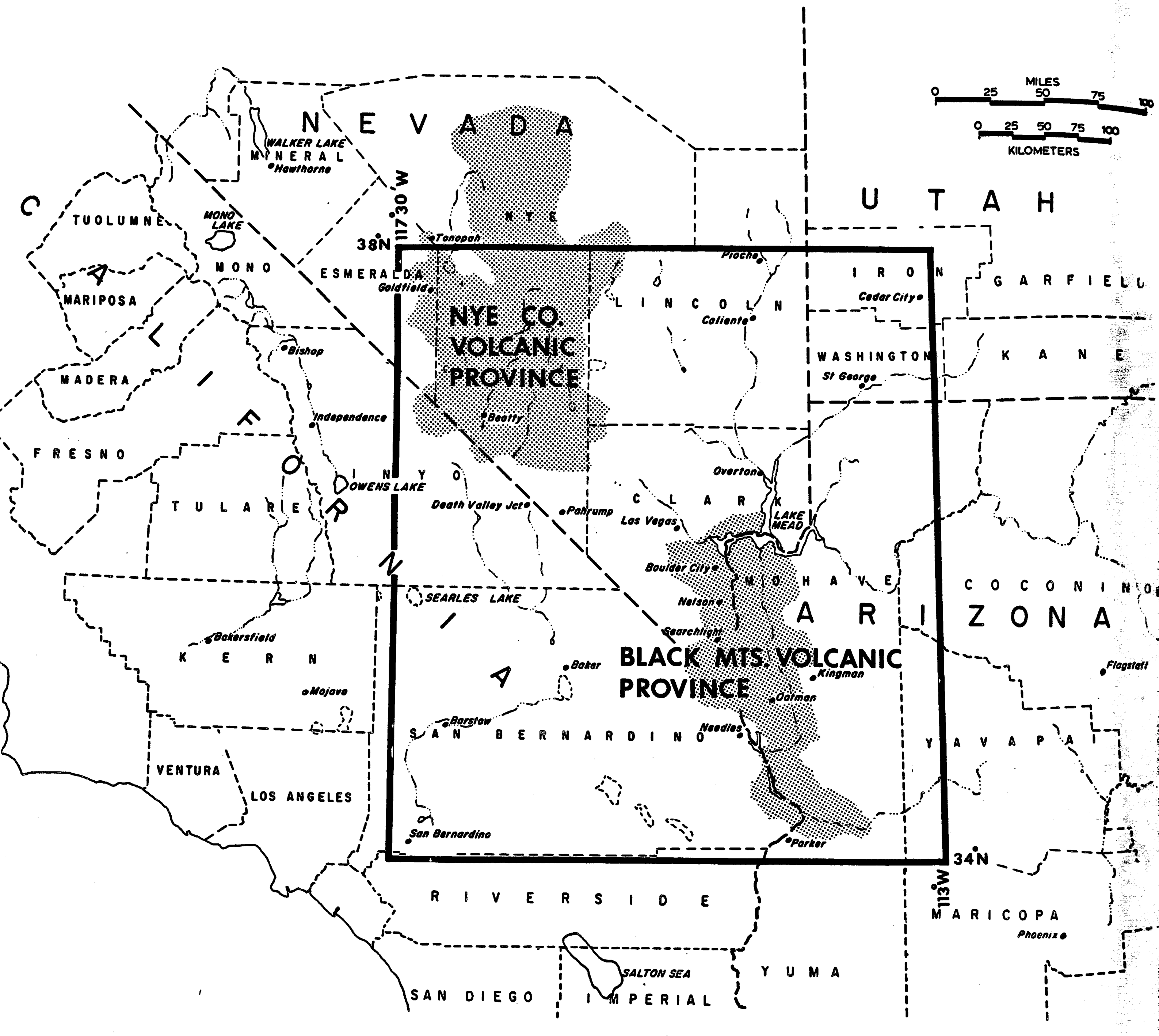


FIGURE 1.—Location map for the area of study. The generalized positions of the Black Mountains and Nye County volcanic provinces are shown with the stippled pattern. The area of the Landsat mosaic of figure 2 (p. XXII) is outlined with a heavy line.

LANDSAT–1 IMAGERY

A false-color mosaic of Landsat–1 multispectral scanner (MSS) composites which covers the area of study is shown in figure 2 (p. XXII). The individual Landsat–1 frames used in this mosaic are identified in figure 3. The false-color composites were prepared from black and white MSS transparencies using a technique developed by MacGalliard and Liggett (1973).

The false-color composites used in figure 2 were produced with the following combination of MSS bands and printing filters:

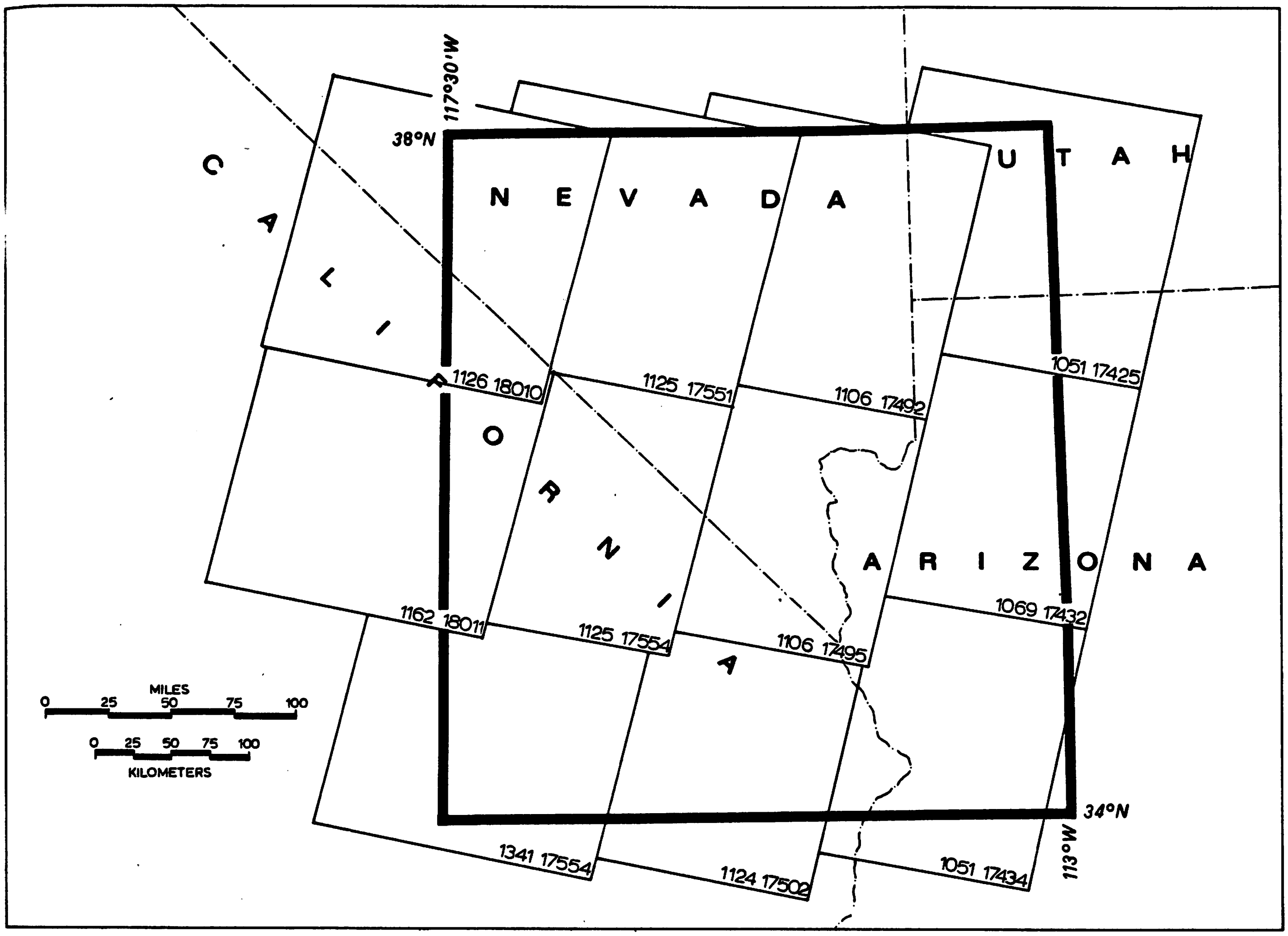


FIGURE 3.—Index map showing the locations and identification numbers of the Landsat–1 MSS frames used in the false-color mosaic of figure 2 (p. XXII). Area of study is outlined.

MSS band	Spectral range	Printing filter
4	Green and yellow (0.5–0.6 µm)	Blue
5	Red (0.6–0.7 µm)	Green
7	Near-infrared (0.8–1.1 µm)	Red

As a result of this MSS band-filter combination, green vegetation appears as intense red due to the high reflectance of vegetation in the near-infrared portion of the spectrum. Most buff-to-brown rock or soil units in the composites reproduce in approximately their natural colors. Neutral colored igneous and sedimentary rocks appear with gray to slightly blue coloring; dark igneous and metamorphic rocks reproduce with dark-brown to steel-gray coloring. Red, iron-rich sedimentary rocks and iron oxide staining associated with hydrothermal alteration appear as yellow coloring, sometimes varying between greenish yellow and orange, depending on the mineralogy and moisture content of the surface material. Water bodies appear dark blue or black due to water's high absorption in the spectral range recorded by the three MSS bands.

Individual Landsat–1 images in the form 1:500,000-scale false-color composites and spectral ratio images (Liggett and research staff, 1974) were studied in comparison with the geologic and structural maps referenced in the bibliography. Analysis of the satellite imagery focused primarily on structural lineaments considered to be possible faults of Cenozoic age. These structures were systematically compared with available geologic maps or checked in the field. The tectonic map of figure 4 is a compilation of those lineaments identified as faults or fault zones which have undergone Cenozoic movement. For the purpose of clarity, faults having traces less than 5 km in length have been eliminated from the compilation.

A map of Cenozoic volcanic and plutonic rocks (fig. 5) was compiled from the referenced published

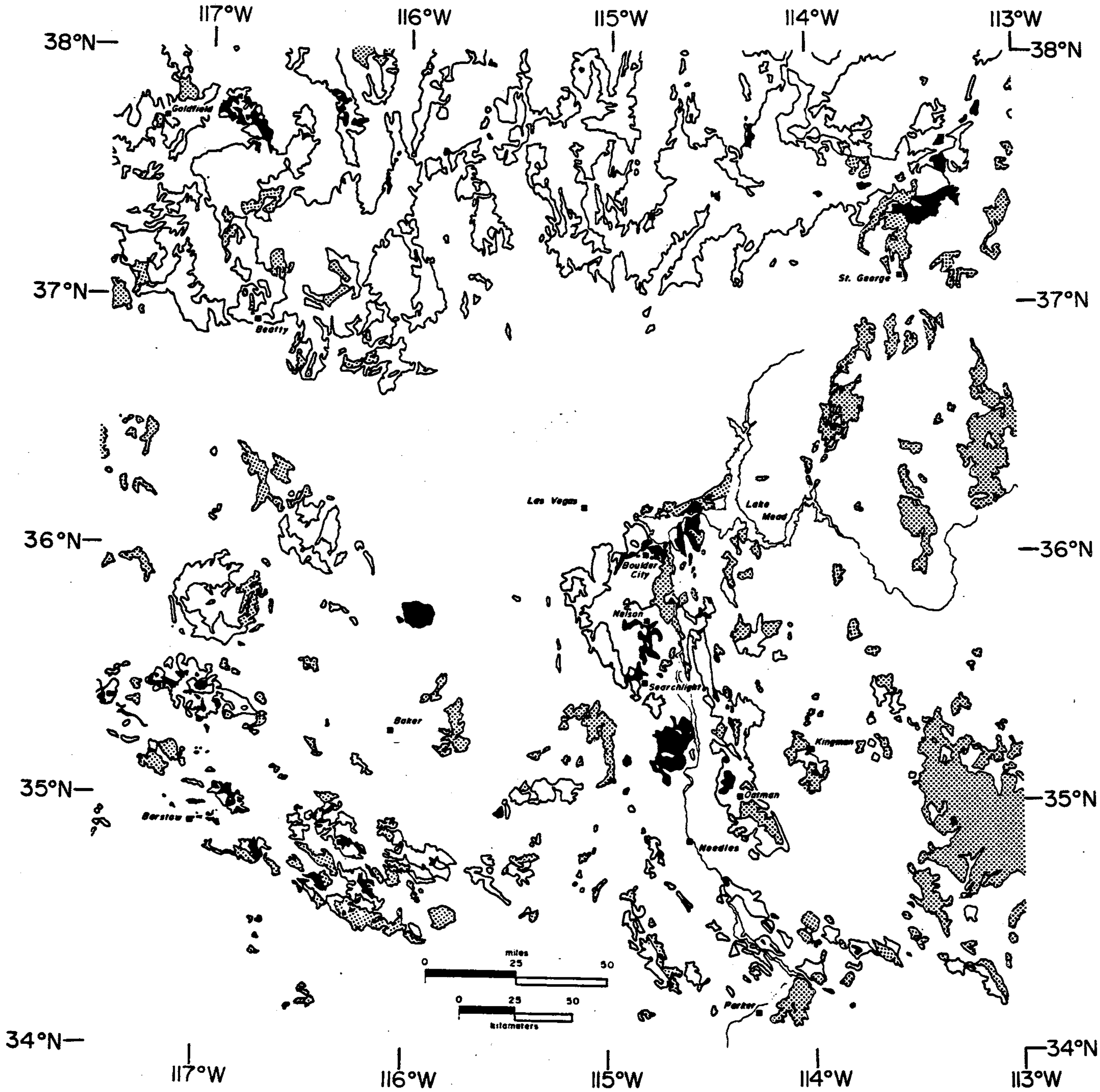


FIGURE 5.—Generalized map of the Cenozoic volcanic and plutonic rocks in the study area. Solid black areas are plutonic bodies of predominantly intermediate composition; the outlined areas are volcanic rocks of generally silicic to intermediate composition; and the stippled areas are volcanic rocks of predominantly basaltic composition.

Basin and Range province to the west and the Colorado Plateau to the east. The physiography of the Basin and Range province, as expressed in the Landsat-1 imagery, is characterized by systems of northerly trending mountain ranges separated by deep alluvial valleys. The province forms a distinct physiographic and structural terrane that can be traced from southern Oregon into northern Mexico.

Much of the Basin and Range province is underlain by Precambrian, Paleozoic, and Mesozoic rocks which were deformed during several orogenies of late Paleozoic and Mesozoic age (Armstrong, 1968). The

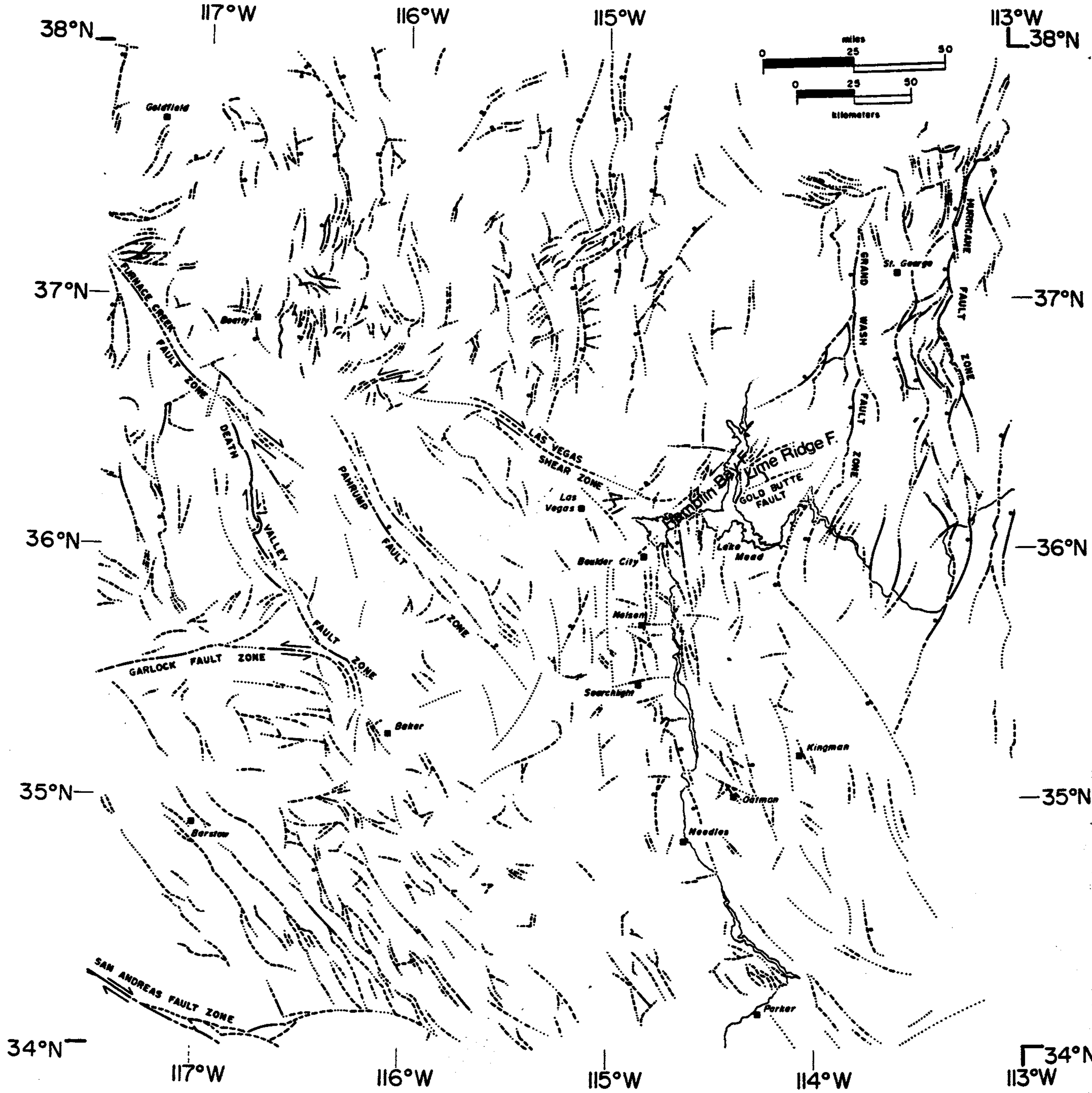


FIGURE 4.—Generalized map of the major Cenozoic fault systems visible in the Landsat–1 imagery of figure 2 (p. XXII). Sense of movement on major strike-slip faults is indicated by arrows; bars and balls are on the down-thrown sides of major normal faults.

sources and from reconnaissance mapping guided by analysis of Landsat–1 imagery. The mapped distribution of volcanic rock types has been generalized to distinguish between those of predominantly silicic to intermediate composition (rhyolite and trachyte through andesite) and those of predominantly basaltic composition (olivine andesite and basalt). Plutonic rocks shown in figure 5 range in composition from granite to gabbro although most are of intermediate composition.

REGIONAL GEOLOGIC SETTING

The area shown in the Landsat–1 mosaic of figure 2 (p. XXII) is located along the border between the formation of the characteristic Basin and Range physiography began in mid-Tertiary time with the onset of regional normal faulting and widespread volcanic and plutonic activity which followed a 60-million-year period of relative crustal stability.

The Cenozoic structure of the province is characterized by northerly trending systems of complex grabens, horsts, and tilted blocks bounded by normal faults (Stewart, 1971). Major range-front faults typically dip at approximately 60° toward the basins with the angle of dip decreasing at depth (Hamilton and Myers, 1966). However, range-front faults having large displacements and dips of less than 25° are not uncommon in the Basin and Range province (Longwell, 1945; Anderson, 1971; Liggett and Ehrenspeck, 1974).

Within the area of study, much of the late Cenozoic volcanic activity is concentrated within two generalized areas referred to here as the Black Mountains and Nye County volcanic provinces (figs. 1 and 5). The volcanic rocks of these provinces are generally silicic to intermediate in composition and were erupted from fissure systems and caldera structures which are closely associated with the normal faults that characterize the Basin and Range province.

Within the Black Mountains volcanic province, erosion has exposed several large, late Cenozoic intrusive bodies which are genetically related to the widespread silicic and intermediate volcanic rocks (fig. 5). In several areas, massive dike swarms are exposed which cut both the crystalline basement and overlying volcanic rocks. These swarms are believed to have been feeders for at least some of the volcanic rocks, and their emplacement can be shown to be both temporally and spatially related to Basin and Range normal faulting (Liggett and Childs, 1974).

Systems of right- and left-lateral strike-slip faults are mapped within the Basin and Range province, generally striking at high angles to the northerly trends typical of the province. The estimates of lateral displacements on these fault systems range up to tens of kilometres. An example is the Las Vegas Shear Zone which can be traced from the southern margin of the Nye County volcanic province to the northern margin of the Black Mountains volcanic province, a distance of nearly 150 km (fig. 4).

Various theories which have been proposed to explain the origin of Basin and Range structure are discussed in excellent summaries by Nolan (1943), Gilluly (1963), Roberts (1968), and Stewart (1971). Most concepts can be separated into the following three categories:

1. Basin and Range structure has resulted from the collapse of the upper crust caused by such mechanisms as lateral transfer of lower crustal material (Gilluly, 1963) or eruption of huge volumes of volcanic rocks (Le Conte, 1889; Mackin, 1960).
2. Basin and Range structure has formed en echelon to movement on deep-seated, conjugate sets of right- and left-lateral strike-slip faults (Shawe, 1965; Sales, 1966).
3. Basin and Range structure is the result of regional crustal extension in an east-west direction (Cook, 1966; Hamilton and Myers, 1966; Roberts, 1968; Stewart, 1971). This process is believed to have occurred by plastic extension of the lower crust, perhaps accompanied by intrusion of plutons beneath Basin and Range grabens (Thompson, 1966). The net amount of crustal extension has been estimated to be as great as 300 km, or 100 percent of the former width of the province (Hamilton and Myers, 1966).

Most current theories of Basin and Range structure presume net crustal extension within the province during late Cenozoic time. Although the causes, mechanisms, and amounts of extension in the province remain controversial, evidence of extension has been documented by geologic mapping and geophysical studies.

TECTONIC MODEL

Based on analysis of Landsat–1 imagery and data published by Fleck (1970a), a tectonic model was proposed by Liggett and Childs (1974) in an attempt to explain the temporal and spatial relationships observed for strike-slip deformation on the Las Vegas Shear Zone and normal faulting, plutonism, volcanism, and related mineralization in the Black Mountains and Nye County volcanic provinces.

Figure 6 shows by means of a simplified model how the Las Vegas Shear Zone is believed to have functioned as an intracontinental "ridge-ridge transform fault" (as defined by Wilson, 1965) which formed in response to east-west crustal extension in the Black Mountains and Nye County volcanic provinces. The geology and chronological development of the Las Vegas Shear Zone and the two areas of inferred crustal extension are summarized below.

LAS VEGAS SHEAR ZONE

A major zone of right-lateral strike-slip deformation passing through Las Vegas Valley was first pos-

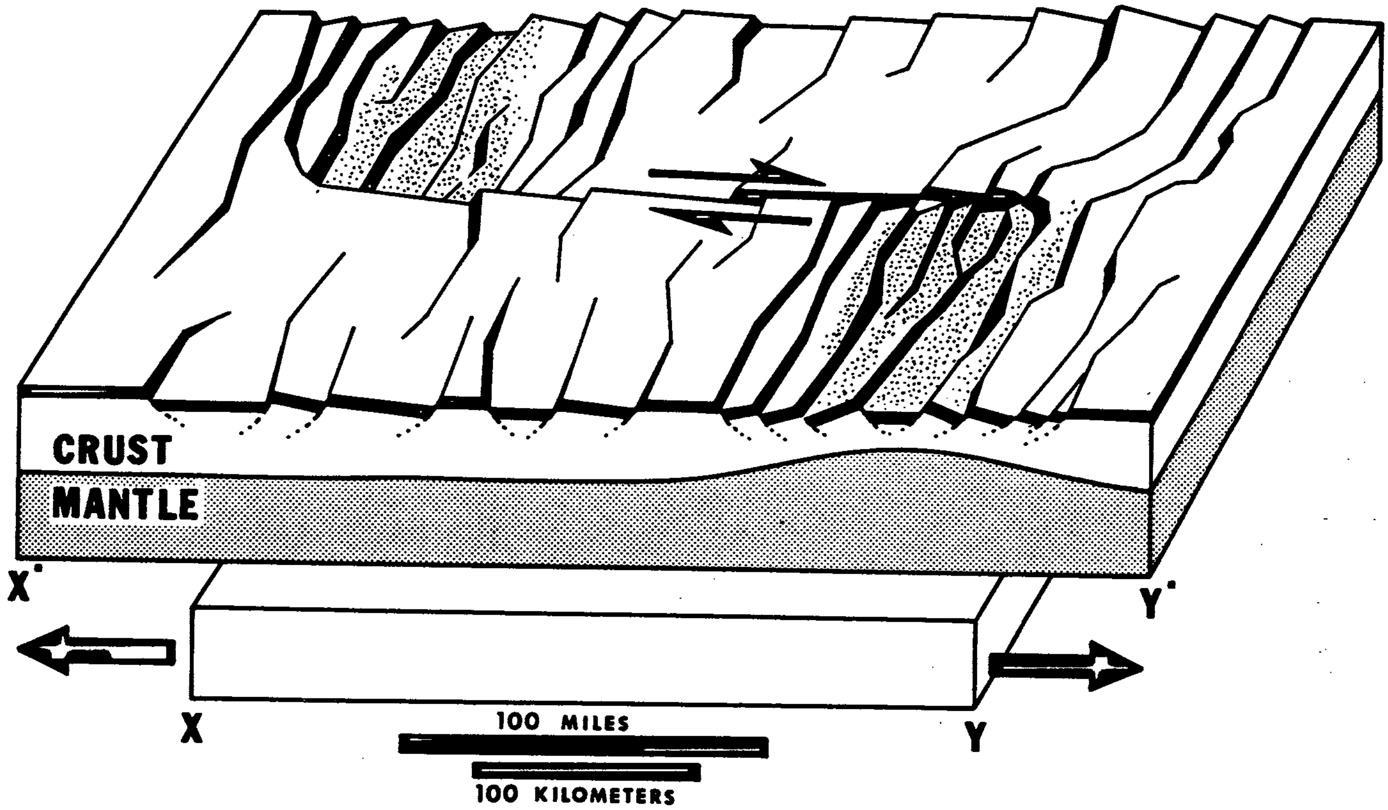


FIGURE 6.—Diagrammatic model relating right-lateral strike-slip movement on the Las Vegas Shear Zone to crustal extension in the two volcanic provinces (stippled patterns). The crustal extension is expressed in the model by major low-angle normal faulting which has caused anomalous thinning of the crust beneath the volcanic provinces. The amount of extension is represented by the increase in length of X–Y to X′–Y′.

tulated by Gianella and Callaghan (1934) in their discussion of the regional implications of the Cedar Mountain earthquake of 1932. The existence of this fault zone was supported by detailed mapping and named the Las Vegas Valley shear zone by Longwell (1960) (see fig. 4).

Indirect evidence suggesting more than 40 km of right-lateral strike-slip on this structure has been cited by several workers. These estimates have been based on displacements of stratigraphic isopachs and sedimentary facies (Longwell and others, 1965; Fleck, 1967; Stewart and others, 1968) and offset of distinctive thrust faults of the Sevier orogenic belt (Longwell and others, 1965; Fleck, 1967). At the scale of the Landsat–1 imagery, evidence for the shear zone is expressed in the flexure of the range trends immediately north and south of the zone. Compensating for the effect of flexure along the shear zone, Fleck (1967) estimated approximately 70 km of right-lateral displacement of features across the deformed belt bordering the shear zone. Of this total, a net slip of 30 km has been estimated for features along the trace of the structure.

The eastern termination of the Las Vegas Shear Zone is thought to lie in the vicinity of Lake Mead where major right-lateral slip on the shear zone gives way to a system of left-lateral oblique-slip faults (fig. 4). Immediately north of Lake Mead, Anderson (1973) has mapped two halves of a Miocene stratovolcano which are displaced left-laterally a distance of approximately 19 km along a northeast-striking fault zone. This structure, called the Hamblin Bay Fault, strikes at a low angle to the easternmost mapped branch of the Las Vegas Shear Zone.

East of the Hamblin Bay Fault, the Gold Butte, and Lime Ridge Faults of Longwell and others (1965) are considered by Anderson (1973) to be left-lateral strike-slip faults. This hypothesis is supported by the flexure of hogback ridges observed adjacent to these faults in the Landsat–1 imagery. The amount of left-lateral strike-slip deformation in this region is poorly known, although it is believed to exceed 19 km (Anderson, 1973). The spatial relationship of these structures to late Cenozoic normal faulting, volcanism, and plutonism in the Saint George-Cedar City area of Utah, suggests that the strike-slip deformation may be mechanically related to localized crustal extension in that area (figs. 4 and 5). An alternate model which involves differential subcrustal flow of the mantle has been proposed by Anderson (1973).

The duration of movement on the Las Vegas Shear Zone has been estimated (Fleck, 1967) from radiometric age determinations of rock units exposed along its trace. A radiometric age date of 15 million years from deformed beds of the Gale Hills Formation suggests that significant movement has occurred on the shear zone since that time. Undeformed basalts of the Muddy Creek Formation along the shear zone have been dated at 10.7 million years. From these dates and field evidence, Fleck (1967) concluded that most strike-slip movement on the Las Vegas Shear Zone probably occurred during the period from 17 to 10 million years ago.

BLACK MOUNTAINS VOLCANIC PROVINCE

The Black Mountains volcanic province is a distinctive igneous and structural terrane which extends southward along the Colorado River from Lake Mead, Nevada, to near Parker, Arizona (figs. 1 and 5). Reconnaissance maps of portions of this region have been published by Longwell (1963), Longwell and others (1965), Wilson and others (1969), and Volborth (1973). Detailed studies of mining districts within the province have been published by Schrader (1917), Ransome (1923), Callaghan (1939), Hansen (1962), Anderson (1971), and Thorson (1971).

The Black Mountains volcanic province is characterized by thick deposits of ignimbrites, flows, and volcaniclastic sediments of generally silicic to intermediate composition, although thin basalt flows are locally widespread. Near Nelson, Nevada, the composite thickness of the late Tertiary volcanic sequence is estimated to be over 5 km (Anderson and others, 1972).

The volcanics were deposited on an erosional surface developed on a crystalline basement of Precambrian gneiss and granite. In parts of the province, the Precambrian basement may have been subjected to metamorphism during a Jurassic orogeny (Volborth, 1973). Both the pre-Tertiary crystalline basement and the overlying volcanic rocks have been intruded by plutons of Miocene age (Anderson and others, 1972; Volborth, 1973). The plutons are generally elongate north-south, and range in composition from leucocratic granite to gabbro, although granite, quartz monzonite, and quartz diorite predominate (Anderson and others, 1972).

Structurally controlled, northerly striking dikes of rhyolite, andesite, and diabase cut both the crystalline basement and the volcanic cover throughout much of the province. In the Newberry Mountains, 25 km southeast of Searchlight, Nevada, a massive swarm of dikes is especially well-exposed forming a belt over 10 km wide. These dikes form a bimodal suite consisting of porphyritic rhyolite and hornblende diabase. Near Nelson, Nevada, dikes of similar compositions are exposed in the lower portions of the volcanic cover, generally decreasing in number upward in the stratigraphic section. It is probable that these dike swarms fed much of the volcanic cover and were in part synchronous with plutonism (Lausen, 1931; Volborth, 1973; Liggett and Childs, 1974).

A close genetic relationship between Tertiary intrusive rocks and chemically equivalent volcanic facies was suggested as early as 1923 by Ransome in a reconnaissance study of the Oatman mining district, Arizona. This conclusion has been supported by more recent mapping and geochemical studies in that district by Thorson (1971). Callaghan (1939) suggested a genetic relationship for an intrusive body and adjacent volcanic rocks in the Searchlight district, Nevada. Based on detailed geochemistry and radiometric age date analysis, Volborth (1973) has proposed a genetic interrelationship for plutonism, hypabyssal dike emplacement and volcanism in nearly the entire western half of the Black Mountains volcanic province. Most of this igneous activity occurred during the period from about 18 to 10 million years before present (Thorson, 1971; Anderson and others, 1972; Volborth, 1973).

The structure of the Black Mountains volcanic province is dominated by northerly striking normal faults, many of which dip at angles of 10° to 20°. This style of deformation has been mapped in detail near Nelson, Nevada, by Anderson (1971) who attributed the low-angle faulting to extreme east-west distension of the upper crust.

Individual normal faults within the Black Mountains volcanic province are estimated to have displacements of 2 to 5 km (Anderson, 1971; Anderson and others, 1972). Within many of the uplifted blocks, erosion has removed the volcanic cover, and exposures of crystalline basement are commonly juxtaposed against thick sequences of late Tertiary volcanic rocks.

Although there is insufficient stratigraphic evidence upon which to base accurate estimates of dip-slip on most of the faults in the Black Mountains volcanic province, the frequency of major low-angle normal faults suggests that crustal extension may exceed 70 km. Estimates of similar magnitude have been made for other portions of the Basin and Range province by Hamilton and Myers (1966); Proffett (1971), and Davis and Burchfiel (1973).

Based on a seismic-refraction profile recorded across the Las Vegas Shear Zone from near Kingman, Arizona, toward the Nye County volcanic province, Roller (1964) has suggested that an anomalously thin crust, 27 km thick, underlies the Black Mountains volcanic province. North of the Las Vegas Shear Zone, the thickness of the crust increases rapidly to 32 km. The seismic-refraction pattern is supported by the existence of a northerly trending Bouguer gravity high (U.S. Air Force, 1968) which is aligned with the trend of the Black Mountains volcanic province. The gravity anomaly suggests an upward bulge of the mantle beneath the volcanic province, possibly the result of isostatic compensation for a thin, distended crust. The high gravity anomaly, like the volcanic province, terminates north of Lake Mead along the Las Vegas Shear Zone and Hamblin Bay Fault systems.

The southern end of the Black Mountains volcanic province is complex and indefinite. The pattern of volcanism, plutonism, and normal faulting within the volcanic province appears to terminate in the vicinity of Parker, Arizona, against a broad zone of northwesterly striking faults. Although this fault system is poorly mapped, field reconnaissance by the authors near Vicksburg, Arizona, and geologic mapping of the Quartzite quadrangle, Arizona, by Miller (1970) indicate right-lateral strike-slip on many of the northwesterly striking faults. The total amount of displacement on this fault system is unknown.

NYE COUNTY VOLCANIC PROVINCE

The Nye County volcanic province lies northwest of the Las Vegas Shear Zone in southern Nye County, Nevada (figs. 1 and 5). This province contains 10 known volcanic centers, at least 5 of which are believed to have formed caldera structures (Ekren, 1968). Detailed geologic studies have been conducted in several mining areas including Rhyolite and Beatty (Cornwall and Kleinhampl, 1964) and Goldfield (Ransome, 1909; Cornwall, 1972; Ashley, 1974). Detailed mapping, stratigraphic, and geophysical studies have been conducted by the U.S. Geological Survey in the U.S. Atomic Energy Commission's Southern Nevada Test Site (Eckel, 1968).

The Tertiary ignimbrites and flows recognized within the Nye County volcanic province are estimated to have a composite thickness of approximately 9 km and a volume of over 11,000 km^3 (Ekren, 1968). Most of these rocks range in composition from dacite to rhyolite, although andesite and basalt flows are locally abundant (Anderson and Ekren, 1968; Ekren, 1968). The volcanic units unconformably overlie a basement of Paleozoic carbonate rocks, which were folded, thrust faulted and metamorphosed during pre-Tertiary time. Several Mesozoic plutons have intruded this Paleozoic basement.

Numerous small plugs, domes, and dikes which range in composition from rhyolite to andesite with minor diabase have intruded the Tertiary volcanic cover. These intrusives are similar in composition to the volcanic rocks and many are believed to have been feeders (Ekren and others, 1971). Most of the volcanism and plutonism within the Nye County volcanic province was synchronous with major normal faulting in a time span from approximately 26.5 to 11 million years ago (Ekren and others, 1968).

The Tertiary deformation within the Nye County volcanic province is dominated by Basin and Range normal faults which have produced a complex horst and graben structure similar to that of the Black Mountains volcanic province. This structural pattern is locally interrupted by caldera subsidence structures, domes, and radial faults related to separate volcanic centers in the province. Arcuate faults which rim caldera structures have displacements estimated on the basis of gravity anomalies and drill hole data to be as great as 2 km (Orkild and others, 1968). Much of the Basin and Range structure is masked by the youngest volcanic rocks, and the full extent of normal faulting is unknown. On the basis of gravity data, several basins are estimated to be filled with as much as 4.8 km of volcanic rock (Healey, 1968); structural control of these basins is suggested by the pronounced northerly trends of the gravity anomalies.

The southern margin of the Nye County volcanic province is formed by the western end of the Las Vegas Shear Zone. Within this area of complex structural intersection, several short northeast-striking faults have been mapped which are believed to have undergone left-lateral strike-slip movement of from 3 to 5 km (Ekren, 1968). No continuation of the Las Vegas Shear Zone has been recognized west of the Nye County volcanic province.

CHRONOLOGY

The structural model proposed here for late-Tertiary deformation in the southern Basin and Range province is supported by the synchronism of strike-slip movement on the Las Vegas Shear Zone and volcanism, plutonism, and normal faulting in the two areas of inferred crustal extension. The chronology of these events is summarized in figure 7.

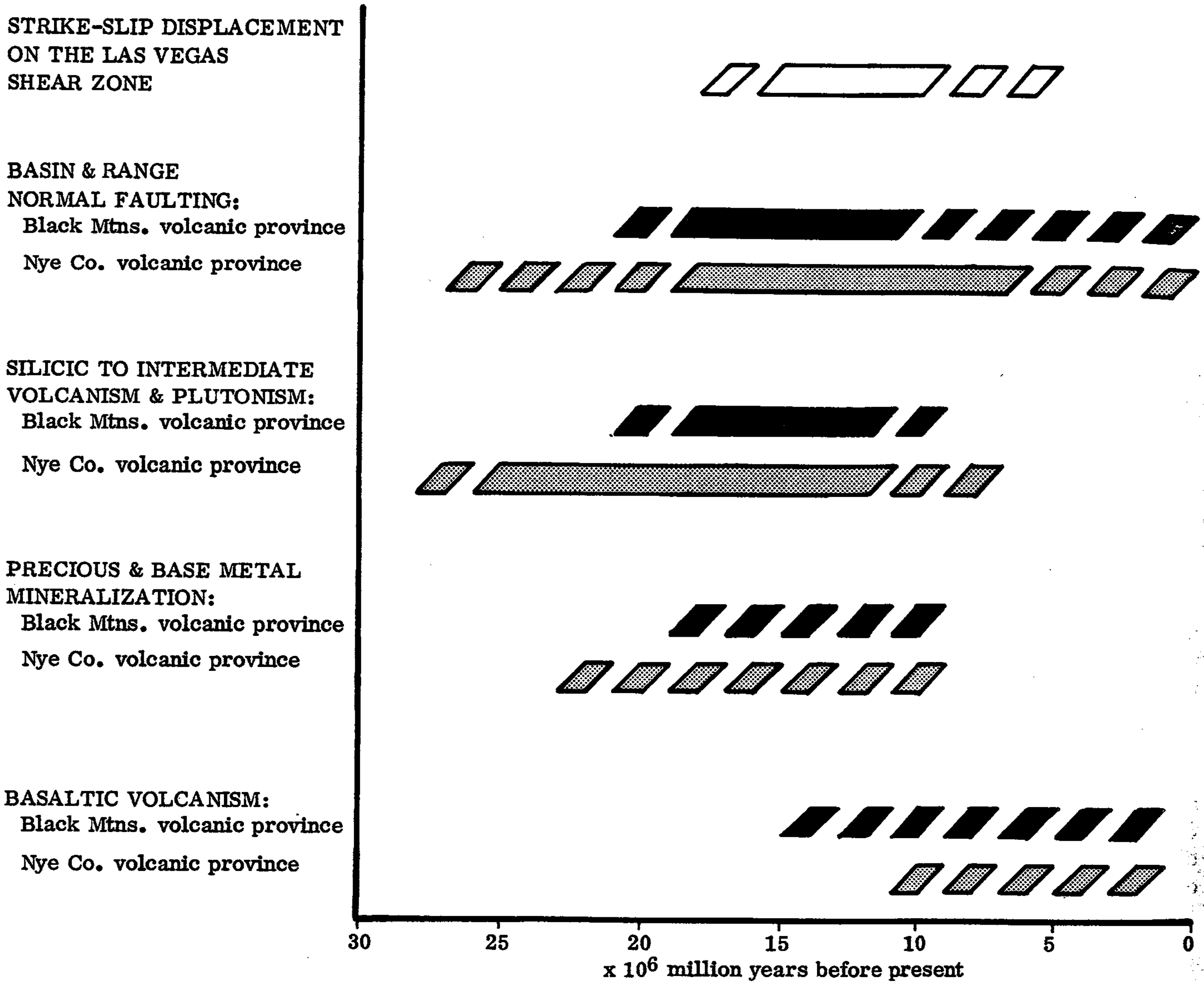


FIGURE 7.—Generalized chronology of strike-slip movement on the Las Vegas Shear Zone and normal faulting, igneous activity, and related mineralization in the Black Mountains and Nye County volcanic provinces.

Within the area of study, the folding and thrust faulting of the Sevier orogeny is believed to have been confined to a relatively brief time span between 90 and 75 million years ago (Fleck, 1970b). The Sevier orogeny appears to have been followed by a long period of relative stability and moderate erosion which by mid-Tertiary time had resulted in a broad terrane of subdued topography.

During mid-Tertiary time the area south of Lake Mead appears to have been the site of a broad arch which shed arkosic conglomerates and fanglomerates containing fragments of Precambrian rock toward the northeast. These sediments overlie an erosional surface cut in the Paleozoic rock of the western Colorado Plateau northeast of Kingman, Arizona. The sediments are conformably overlain by the Peach Springs Tuff of Young (1966) which has been variously dated at 18.3±0.6 and 16.9±0.4 million years (Young and Brennan, 1974). These relationships indicate that by Miocene time erosion had unroofed Precambrian basement in the arch south of Lake Mead and that major normal faulting had not yet separated depositional areas on the Colorado Plateau from source areas in the ancestral Basin and Range province. Following deposition of the Peach Springs Tuff, Basin and Range faulting disrupted the northeast-flowing drainage, leading to formation of a new pattern of isolated structural depressions filled by basin deposits (Lucchitta, 1972).

According to Anderson and others (1972), in the core of the Black Mountains volcanic province the oldest volcanic rocks overlying the Precambrian crystalline basement are tuff units believed to be 18.6 million years old; the youngest volumetrically significant volcanic units in the area consist of tuffs and flows dated at 12.7 million years; and most of the epizonal plutonic rocks in the Black Mountains volcanic province range in age from 17 to 12 million years.

In the Nye County volcanic province, the chronology of volcanism and structural deformation is similar to that in the Black Mountains volcanic province. An erosional surface of low relief developed on the folded and thrust faulted Paleozoic basement in early Tertiary time. This surface was covered by a widespread welded tuff unit dated at 26.5 million years (Ekren and others, 1968). Shortly after the eruption of this tuff, normal faults with northeast and northwest strikes began to develop. The typical north-trending Basin and Range normal faults first began to form in the Nye County volcanic province after deposition of a tuff breccia dated at 17.8 million years. The present mountain ranges are believed to have been well defined prior to eruption of the Thirsty Canyon Tuff dated at 7 million years (Ekren and others, 1968), although minor normal faulting has continued to the present.

Albers and Kleinhampl (1970) have studied the genetic relationships between precious metal mineralization and spatially associated volcanic centers of Cenozoic age throughout Nevada. On the basis of radiometric age determinations these workers suggest that mineralization was at least temporally related to the late stages of igneous activity in the associated volcanic centers. The available evidence suggests similar relationships in the Black Mountains volcanic province.

In summary, the first major normal faulting, volcanism, and plutonism in the Black Mountains and Nye County volcanic provinces began in the period from approximately 26 to 18 million years ago. Right-lateral strike-slip movement on the Las Vegas Shear Zone appears to have begun about 17 million years ago and to have continued with synchronous igneous activity and extensional normal faulting in both volcanic provinces. Major strike-slip movement, igneous activity, and related mineralization ended by approximately 10 million years ago, although Basin and Range normal faulting and intermittent basaltic volcanism have continued to the present time.

STRUCTURAL CONTROL OF MINERALIZATION IN THE BLACK MOUNTAINS VOLCANIC PROVINCE

The gold, silver, and base metal mineralization of Cenozoic age in the Black Mountains and Nye County volcanic provinces is both spatially and temporally related to the igneous activity and structural deformation of these two areas. The structural control of mineralization in the Black Mountains volcanic province is of particular interest since both the regional structural setting of the province and the key structural trends which have localized mineralization are visible in the Landsat–1 imagery.

The major ore production in the Black Mountains volcanic province has come from the Eldorado and Searchlight districts in southern Clark County, Nevada, and the Oatman and Katherine districts east of the Colorado River in Mohave County, Arizona (fig. 8). Small mine workings and prospects are found throughout the province. The local geology and structural controls of mineralization in these districts are summarized below.

ELDORADO MINING DISTRICT

The Eldorado mining district is located in southern Clark County, Nevada, approximately 35 km south of Lake Mead. Most of the mines in the district are located within a 10-km radius of the town of Nelson (fig. 8). The host rocks for mineralization include Precambrian gneiss and Miocene plutonic and volcanic rocks of silicic to intermediate composition.

The structure of the Eldorado mining district is dominated by closely spaced, northerly striking normal faults, which commonly have dips of less than 30°. Anderson (1971) has attributed this system of low-angle normal faults to tensional rifting and distension of the upper crust, possibly related to the intrusion of a granitic pluton at shallow depth. In spite of the strong north-south structural grain, mineralization in the district is in almost all cases controlled by a system of steeply dipping, east-west striking faults. This transverse structural trend is well expressed in the Landsat–1 imagery.

The mineralization occurs in veins of fault breccia cemented with quartz and calcite gangue. The gold and silver are believed to have been contained in disseminated pyrite with minor galena, sphalerite, and chalcopyrite; however, the original sulfide minerals are now largely oxidized (Hansen, 1962). The veins typically show evidence of multiple episodes of fault movement followed by cementation and mineralization; many of the transverse faults along which the veins were formed are known to have undergone strike-slip movement (Anderson, 1971).

Total production from the Eldorado mining district during the period 1907–1945 is cited by Hansen (1962) as 101,522 oz gold and 2,339,353 oz silver, with minor production of copper and lead.

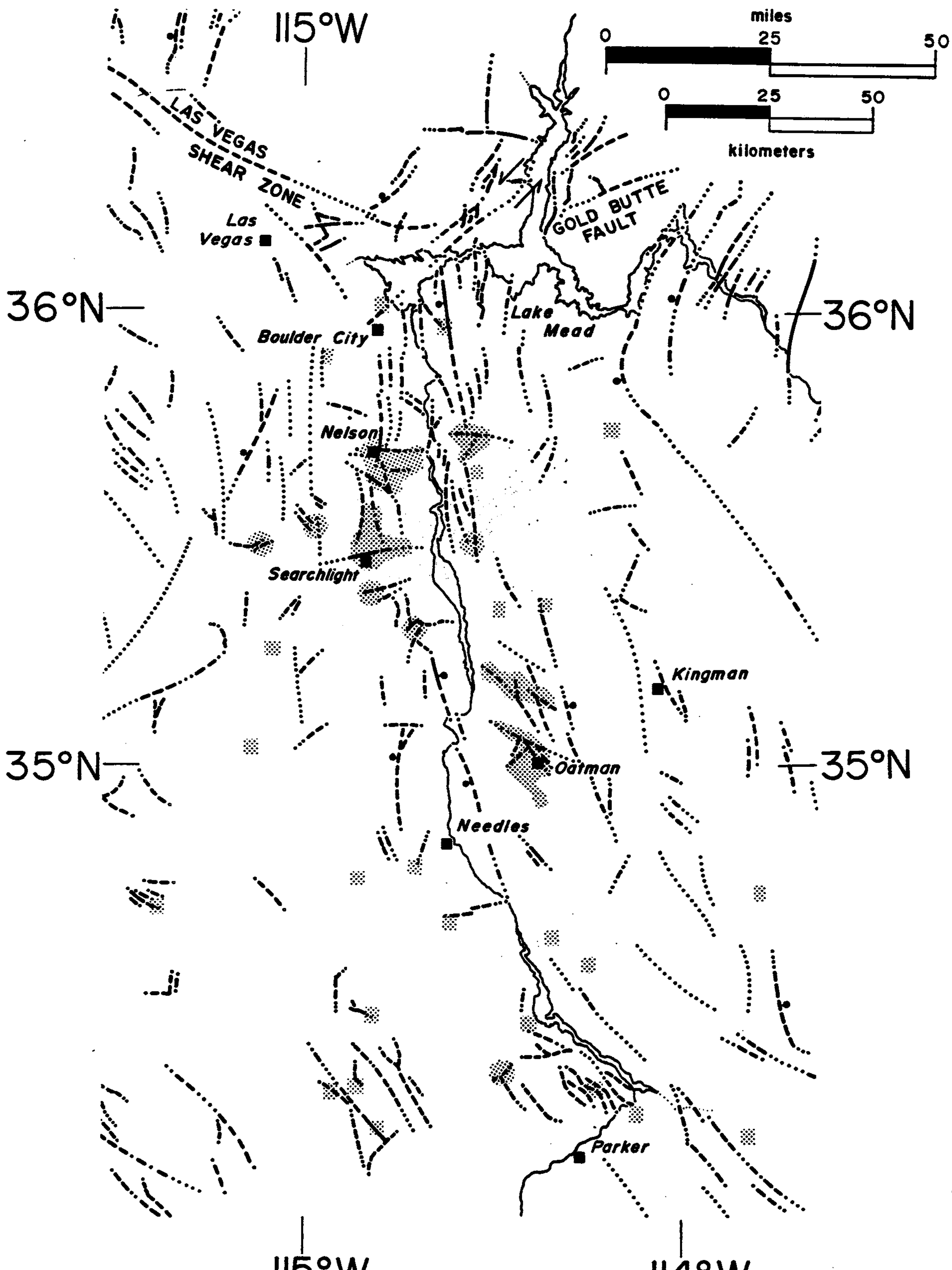


FIGURE 8.—Areas of late Cenozoic precious and base metal mineralization (stippled) in the Black Mountains volcanic province in relation to the Cenzoic fault systems visible in the Landsat imagery.

A relatively small mining area known as the Weaver district is located in the northern Black Mountains of Arizona due east of the Eldorado mining district. Like the Eldorado district, precious metals and minor copper occur in quartz and calcite vein systems which generally strike from N. 45° to 100° E., transverse to the structural grain of the province. Host rocks include Precambrian gneiss, Miocene volcanic rocks, and granites of probable Tertiary age. Although exact production figures are unavailable, total production from the Weaver district is believed to be small.

SEARCHLIGHT MINING DISTRICT

The Searchlight mining district is located at the southern end of the Eldorado Mountains, approximately 30 km south of the Eldorado mining district (fig. 8). The most prominent geologic feature of the district is a large quartz monzonite pluton of Miocene age which intruded a crystalline basement of Precambrian gneiss and granite and Tertiary volcanic rocks of intermediate composition (Callaghan, 1939). Although the shape of the pluton is generally controlled by the northerly structural grain of the Black Mountains volcanic province, the pluton is terminated on the south by a major east-west striking fault (Volborth, 1973).

Gold, silver, copper, and lead mineralization in the Searchlight district occurs in structurally controlled vein systems in and adjacent to the quartz monzonite pluton. Approximately 25 of the 34 productive veins in the district strike between N. 80° and 123° E.; most of these dip steeply to the south (Callaghan, 1939). The veins contain clasts of brecciated country rock usually cemented with quartz gangue although calcite and adularia occur locally. As in the Eldorado district, the veins show evidence of multiple episodes of fault movement followed by cementation and mineralization. Although the sense and amount of movement on the east-west striking faults is not known, these transverse structures contain the principal mineralization of the district.

Production from the Searchlight district for the period 1902–1934 is reported by Callaghan (1939) to be 207,570 oz gold, 219,596 oz silver, 650,550 lb copper, and 1,675,560 lb lead.

An area of numerous small gold and silver mines is located in Tertiary volcanic rocks east of the Colorado River, approximately 30 km east-northeast of the Searchlight district. The largest producing mine in this area is known as the Golden Door mine. The major mineralized quartz-calcite veins in the area strike generally eastward with generally steep dips; subordinate veins are irregular in strike and have shallow dips. Recent development and exploration work in the Golden Door mine area has concentrated on flat-lying volcanic units which have been preferentially silicified and mineralized.

OATMAN MINING DISTRICT

The Oatman mining district is located east of the Colorado River on the western slope of the Black Mountains, approximately 115 km south of Lake Mead (fig. 8). Most of the production from the Oatman district has come from vein systems within a thick sequence of late Tertiary volcanic rocks of silicic to intermediate composition. These volcanic rocks unconformably overlie a crystalline basement of Precambrian granite and gneiss. Both the crystalline basement and overlying volcanic rocks were locally introduced by dikes and small granitic plutons which are believed to be genetically related to the volcanic cover (Thorson, 1971).

The mineralized veins were formed within transverse fault zones, most of which range in strike from west to northwest and dip steeply toward the north or northeast. Several of the northwest-striking faults have undergone right-lateral strike-slip movement. The veins range in width from a few centimetres to several metres, and typically contain clasts of country rock cemented with a gangue of coarsely crystalline quartz and calcite with smaller amounts of microcrystalline adularia and fluorite. The veins commonly show a pronounced banding in cross section, produced by successive episodes of fault movement, cementation, and mineralization. Lausen (1931) reported five distinct stages of quartz deposition in the mineralized veins of which the later stages generally contain the highest ore values. Host rocks adjacent to the veins commonly show evidence of propylitic alteration.

A small amount of gold and silver has been produced from several mines in an area known as the Katherine mining district, located approximately 25 km north-northwest of Oatman. The veins in the Katherine district are similar in mineralogy to those at Oatman, although unlike the Oatman veins, they occur primarily within the Precambrian granitic basement which has been locally intruded by dikes and plugs of rhyolite (Lausen, 1931). The mineralized veins in the Katherine mining district generally strike at high angles to the northerly structural grain of the Black Mountains volcanic province.

The combined value of gold and silver production from the Oatman and Katherine mining districts is reported by Lausen (1931) as $35,417,926 for the period from 1897 through 1928. This is estimated to represent a metal production of approximately

1,714,000 oz t gold and 870,000 oz t silver from ore averaging approximately 0.6 oz of gold and 0.3 oz of silver per ton.

DISCUSSION

Field reconnaissance and study of geologic literature guided by analysis of Landsat–1 imagery have led to a model which relates strike-slip deformation on the Las Vegas Shear Zone to normal faulting, volcanism, and plutonism in the Black Mountains and Nye County volcanic provinces. The Las Vegas Shear Zone is believed to have functioned as a ridge-ridge transform fault, which separated these two areas of east-west crustal extension. Geochronology and field evidence indicate that the right-lateral strike-slip movement on the Las Vegas Shear Zone was synchronous with normal faulting, igneous activity, and related mineralization in both volcanic provinces.

The east-west crustal extension in the Black Mountains volcanic province is represented by northerly trending systems of normal faults, dike swarms, and shallow plutons. The pronounced north-trending structural grain of the province is locally crossed by transverse fault systems, several of which are known to have undergone strike-slip movement. These transverse structures are well expressed in the Landsat–1 imagery and have played an important role in localizing late Cenozoic precious and base metal mineralization within the volcanic province.

In several areas within the Black Mountains volcanic province a complex interrelationship has been observed between the normal and strike-slip fault systems. Many of the northerly striking normal faults terminate against transverse strike-slip faults without apparent offset. In addition, transverse strike-slip faults are frequently observed to end by turning abruptly in strike to merge with north-striking normal faults. Examples have been mapped by Anderson (1971) and Volborth (1973) in parts of the Boulder City and Nelson 15′ quadrangles. This interrelationship of strike-slip and normal faults suggests that these structures may be mechanically related as illustrated in the diagrammatic model of figure 9. This model suggests that the transverse strike-slip faults in the Black Mountains volcanic province may have formed as minor transform faults which separated areas of differential crustal extension.

The mechanisms by which the transverse faults have controlled the location of mineralization are not well understood. It is possible that the steep dips of these structures provided effective conduits for ascending hydrothermal solutions. Because each transverse fault is mechanically linked to a system of normal faults, it would remain active, and thus open to ascending solutions, over prolonged periods of extensional deformation. In contrast, individual gently dipping normal faults could be easily sealed by a variety of processes and are not likely to have afforded direct channelways for mineralizing solutions.

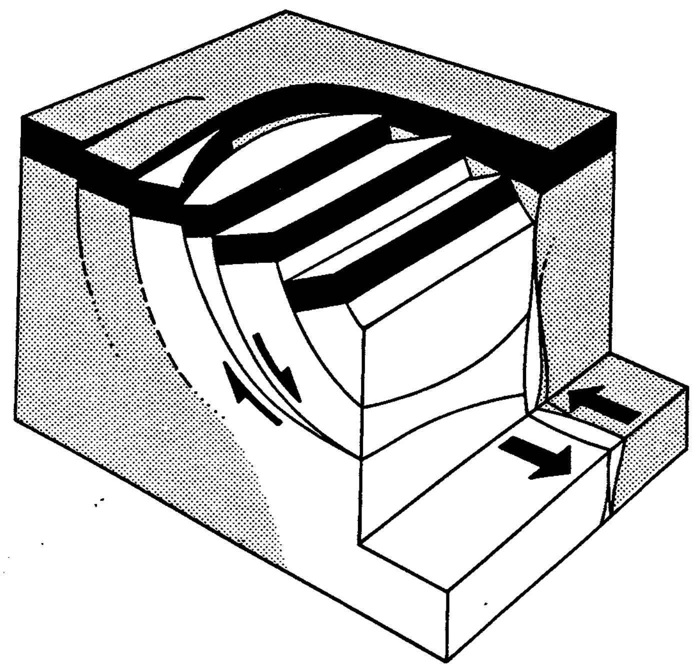


FIGURE 9.—Diagrammatic model illustrating the mechanical interrelationship of strike-slip and normal faulting believed to exist in the Black Mountains volcanic province. Note that movement on the strike-slip fault zone is mechanically linked to slip on the system of low-angle normal faults.

The model proposed here for the regional structural setting of the Black Mountains volcanic province unifies many of the temporal and spatial relationships recognized for the Cenozoic tectonics, igneous activity, and mineralization in this part of the Basin and Range province. Although many details of the structural deformation and the physicochemical controls of magma genesis and mineralization are not understood, the structural model and specific structural features expressed in the Landsat–1 imagery provide an effective basis for extrapolating mineralized trends and for selecting blind or poorly exposed targets for further investigation.

The application of satellite remote-sensing techniques to mineral exploration is not likely to replace the use of conventional methods. However, the synoptic perspective of satellite imagery can provide a valuable framework for synthesizing diverse geologic data and for guiding field research to test working hypotheses. Integrated with other exploration techniques as part of a systematic program, satellite imagery can be a valuable tool in reconnaissance exploration.

ACKNOWLEDGMENTS

This investigation benefited greatly from the work of R. E. Anderson, R. J. Fleck, C. R. Longwell, A. Volborth, and the other individuals cited in the references. Wally MacGalliard prepared the false-color composites of Landsat-1 MSS imagery used in this investigation, and H. E. Ehrenspeck compiled much of the data presented in figures 4 and 5. The authors, however, are solely responsible for errors in fact or interpretation.

This research was supported jointly by Cyprus Mines Corporation and the National Aeronautics and Space Administration under Contract NAS5–21809.

REFERENCES CITED

Albers, J. P., and Kleinhampl, F. J., 1970, Spatial relation of mineral deposits to Tertiary volcanic centers in Nevada: U.S. Geol. Survey Prof. Paper 700–C, p. C1–C10.

Anderson, R. E., 1971, Thin skin distension in Tertiary rocks of southeastern Nevada: Geol. Soc. America Bull., v. 82, p. 43–58.

———1973, Large-magnitude late Tertiary strike-slip faulting north of Lake Mead, Nevada: U.S. Geol. Survey Prof. Paper 794, 18 p.

Anderson, R. E., and Ekren, E. B., 1968, Widespread Miocene igneous rocks of intermediate composition, southern Nye County, Nevada, *in* Eckel, E. B., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 57–63.

Anderson, R. E., Longwell, C. R., Armstrong, R. L., and Marvin, R. F., 1972, Significance of K–Ar ages of Tertiary rocks from the Lake Mead region, Nevada-Arizona: Geol. Soc. America Bull., v. 83, p. 273–288.

Armstrong, R. L., 1968, Sevier orogenic belt in Nevada and Utah: Geol. Soc. America Bull., v. 79, p. 429–458.

Ashley, R. P., 1974, Goldfield mining district, *in* Guidebook to the geology of four Tertiary volcanic centers in central Nevada: Nevada Bur. of Mines and Geology Rept. 19, p. 49–66.

Callaghan, Eugene, 1939, Geology of the Searchlight district, Clark County, Nevada: U.S. Geol. Survey Bull. 906 D, p. 135–185.

Cook, K. L., 1966, Rift system in the Basin and Range province, *in* The world rift system: Canada Geol. Survey Paper 66–14, p. 246–279.

Cornwall, H. R., 1972, Geology and mineral deposits of southern Nye County, Nevada: Nevada Bur. Mines and Geology Bull. 77, 49 p.

Cornwall, H. R., and Kleinhampl, F. J., 1964, Geology of Bullfrog quadrangle and ore deposits related to Bullfrog Hills caldera, Nye County, Nevada, and Inyo County, California: U.S. Geol. Survey Prof. Paper 454–J, p. J1–J25.

Davis, G. A., and Burchfiel, B. C., 1973, Garlock fault: An intracontinental transform structure, southern California: Geol. Soc. America Bull., v. 84, p. 1407–1422.

Eckel, E. B., ed., 1968, Nevada Test Site: Geol. Soc. America Mem. 110, 290 p.

Ekren, E. B., 1968, Geologic setting of Nevada Test Site and Nellis Air Force Range, *in* Eckel, E. B., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 11–19.

Ekren, E. B., Anderson, R. E., Rogers, C. L., and Noble, D. C., 1971, Geology of northern Nellis Air Force Base Bombing and Gunnery Range, Nye County, Nevada: U.S. Geol. Survey Prof. Paper 651, 91 p.

Ekren, E. B., Rogers, C. L., Anderson, R. E., and Orkild, P. P., 1968, Age of Basin and Range normal faults in Nevada Test Site and Nellis Air Force Range, Nevada, *in* Eckel, E. B., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 247–250.

Fleck, R. J., 1967, The magnitude, sequence, and style of deformation in southern Nevada and eastern California (Ph.D. thesis): Berkeley, Univ. California, 92 p.

———1970a, Age and possible origin of the Las Vegas shear zone, Clark and Nye Counties, Nevada: Geol. Soc. America, Abs. with Programs (Rocky Mountain sect.), v. 2, no. 5, p. 333.

———1970b, Tectonic style, magnitude, and age of deformation in the Sevier orogenic belt in southern Nevada and eastern California: Geol. Soc. America Bull., v. 81, p. 1705–1720.

Gianella, V. P., and Callaghan, E., 1934, The earthquake of December 20, 1932, at Cedar Mountain, Nevada, and its bearing on the genesis of Basin Range structure: Jour. Geology, v. 42, no. 1, p. 1–22.

Gilluly, J., 1963, The tectonic evolution of the western United States: Geol. Soc. London Quart. Jour., v. 119, p. 133–174.

Hamilton, W., and Myers, W. B., 1966, Cenozoic tectonics of the western United States: Rev. Geophysics, v. 4, no. 4, p. 509–549.

Hansen, S. M., 1962, The geology of the Eldorado mining district, Clark County, Nevada (Ph.D. thesis): Rolla, Univ. Missouri, 262 p.

Healey, D. L., 1968, Application of gravity data to geologic problems at Nevada Test Site, *in* Eckel, E. B., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 147–156.

Lausen, Carl, 1931, Geology and ore deposits of the Oatman and Katherine districts, Arizona: Arizona Bur. Mines and Geol. Series no. 6, Bull. 131, 126 p.

Le Conte, J., 1889, On the origin of normal faults and of the structure of the Basin region: Am. Jour. Sci., third series, v. 38, no. 226, p. 257–263.

Liggett, M. A., and Childs, J. F., 1974, Crustal extension and transform faulting in the southern Basin Range Province: Argus Exploration Company, NASA Rept. Inv., NASA–CR–137256, E74–10411, 54 p.

Liggett, M. A., and Ehrenspeck, H. E., 1974, Pahranagat shear system, Lincoln County, Nevada: Argus Exploration Company, NASA Rept. Inv., NASA–CR–136388, E74–10206, 12 p.

Liggett, M. A., and research staff, 1974, A reconnaissance space sensing investigation of crustal structure for a strip from the eastern Sierra Nevada to the Colorado Plateau: Argus Exploration Company, NASA Final Rept. Inv., NASA–CR–139434, E74–10705, 156 p., plus 16 appendices, 17 figures, and 8 plates.

Longwell, C. R., 1945, Low-angle normal faults in the Basin Range Province: Am. Geophys. Union Trans., v. 26, p. 107–118.

———1960, Possible explanation of diverse structural patterns in southern Nevada: Am. Jour. Sci. (Bradley Volume), v. 258–A, p. A192–A203.

———1963, Reconnaissance geology between Lake Mead and Davis Dam, Arizona-Nevada: U.S. Geol. Survey Prof. Paper 374–E, p. E1–E51.

Longwell, C. R., Pampeyan, E. H., Bowyer, B., and Roberts, R. J., 1965, Geology and mineral deposits of Clark County, Nevada: Nevada Bur. Mines and Geology Bull. 62, 218 p.

Lucchitta, I., 1972, Early history of the Colorado River in the Basin and Range province: Geol. Soc. America Bull., v. 83, p. 1933–1948.

MacGalliard, Wally, and Liggett, M. A., 1973, False-color compositing of ERTS–1 MSS imagery: Argus Exploration Company, NASA Rept. Inv., NASA–CR–135859, E74–10018, 5 p.

Mackin, J. H., 1960, Structural significance of Tertiary volcanic rocks in southwestern Utah: Am. Jour. Sci., v. 258, p. 81–131.

Miller, F. K., 1970, Geologic map of the Quartzite quadrangle, Yuma County, Arizona: U.S. Geol. Survey Map GQ–841, scale 1:62,500.

Nolan, T. B., 1943, The Basin and Range province in Utah, Nevada and California: U.S. Geol. Survey Prof. Paper 197–D, p. D141–D196.

Orkild, P. P., Byers, F. M., Jr., Hoover, D. L., and Sargent, K. A., 1968, Subsurface geology of Silent Canyon caldera, Nevada Test Site, Nevada, *in* Eckel, E. B., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 77–86.

Proffett, J. M., Jr., 1971, Late Cenozoic structure in the Yerington district, Nevada, and the origin of the Great Basin: Geol. Soc. America, Abs. with Programs (Cordilleran sect.), v. 3, no. 2, p. 181.

Ransome, F. L., 1909, The geology and ore deposits of Goldfield, Nevada: U.S. Geol. Survey Prof. Paper 66, 258 p.

———1923, Geology of the Oatman gold district, Arizona: A preliminary report: U.S. Geol. Survey Bull. 743, 58 p.

Roberts, R. J., 1968, Tectonic framework of the Great Basin: Rolla, Univ. Missouri Res. Jour., no. 1, p. 101–119.

Roller, J. C., 1964, Crustal structure in the vicinity of Las Vegas, Nevada, from seismic and gravity observations: U.S. Geol. Survey Prof. Paper 475–D, p. D108–D111.

Sales, J. K., 1966, Structural analysis of the Basin Range province in terms of wrench faulting (Ph.D. dissert.): Reno, Univ. Nevada, 289 p.

Schrader, F. C., 1917, Geology and ore deposits of Mohave County, Arizona: Am. Inst. Mining Engineers Trans., v. 56, p. 195–236.

Shawe, D. R., 1965, Strike-slip control of Basin-Range structure indicated by historical faults in western Nevada: Geol. Soc. America Bull., v. 76, p. 1361–1378.

Stewart, J. H., 1971, Basin and Range structure: A system of horsts and grabens produced by deep-seated extension: Geol. Soc. America Bull., v. 82, p. 1019–1044.

Stewart, J. H., Albers, J. P., and Poole, F. G., 1968, Summary of regional evidence for right-lateral displacement in the western Great Basin: Geol. Soc. America Bull., v. 79, p. 1407–1414.

Thompson, G. A., 1966, The rift system of the western United States, *in* The world rift system: Canada Geol. Survey Paper 66–14, p. 280–290.

Thorson, J. P., 1971, Igneous petrology of the Oatman district, Mohave County, Arizona (Ph.D. dissert.): Santa Barbara, Univ. California, 173 p.

U.S. Air Force Aeronautical Chart and Information Center, 1968, Transcontinental Geophysical Survey (35°–39° N) Bouguer gravity map from 112° W. longitude to the coast of California: U.S. Geol. Survey Misc. Geol. Inv. Map I–532–B.

Volbroth, Alexis, 1973, Geology of the granite complex of the Eldorado, Newberry and northern Dead Mountains, Clark County, Nevada: Nevada Bur. Mines and Geology Bull. 80, 40 p.

Wilson, E. D., Moore, R. T., and Cooper, J. R., 1969, Geologic map of Arizona: U.S. Geol. Survey, scale 1:500,000.

Wilson, J. T., 1965, A new class of faults and their bearing on continental drift: Nature, v. 207, p. 343–347.

Young, R. A., 1966, Cenozoic geology along the edge of the Colorado Plateau in northwestern Arizona: Dissert. Abs., sec. B, v. 27, no. 6, p. 1994.

Young, R. A., and Brennan, W. J., 1974, Peach Springs Tuff: Its bearing on structural evolution of the Colorado Plateau and development of Cenozoic drainage in Mohave County, Arizona: Geol. Soc. America Bull., v. 85, p. 83–90.

ADDITIONAL REFERENCES USED IN COMPILING FIGURES 4 AND 5

Albers, J. P., and Stewart, J. H., 1972, Geology and mineral deposits of Esmeralda County, Nevada: Nevada Bur. Mines and Geology Bull. 78, 80 p.

Anderson, R. E., 1969, Notes on the geology and paleohydrology of the Boulder City pluton, southern Nevada: U.S. Geol. Survey Prof. Paper 650–B, p. B35–B40.

Bassett, A. M., and Kupfer, D. H., 1964, A geologic reconnaissance in the southeastern Mojave Desert, California: California Div. Mines and Geol. Spec. Rept. 83, 43 p.

Bechtold, I. C., Liggett, M. A., and Childs, J. F., March 1973, Regional tectonic control of Tertiary mineralization and Recent faulting in the southern Basin-Range Province: An application of ERTS–1 data, *in* Freden, S. C., Mercanti, E. P., and Becker, M. A., eds., Symposium on significant results obtained from ERTS–1, New Carrollton, Maryland, v. 1, sect. A, paper G–21, NASA–SP–327, p. 425–432.

Bishop, C. C., 1963, Geologic map of California, Needles sheet, Olaf P. Jenkins edition: California Div. Mines and Geology, scale 1:250,000.

Bowen, O. E., Jr., 1954, Geology and mineral deposits of Barstow quadrangle, San Bernardino County, California: California Div. Mines and Geology Bull. 165, 208 p.

Carlson, J. E., and Willden, Ronald, 1968, Transcontinental Geophysical Survey (35°–39° N) geologic map from 112° W longitude to the coast of California: U.S. Geol. Survey Misc. Geol. Inv. Map I–532–C, scale 1:1,000,000.

Childs, J. F., 1973a, The Salt Creek Fault, Death Valley, California (abs.): Argus Exploration Company, NASA Rept. Inv., NASA–CR–133141, E73–10774, 6 p.

———1973b, A major normal fault in Esmeralda County, Nevada (abs.): Argus Exploration Company, NASA Rept. Inv., NASA–CR–135859, E74–10018, 6 p.

Clary, M. R., 1967, Geology of the eastern part of the Clark Mountains Range, San Bernardino County, California: California Div. Mines and Geology Map Sheet 6.

Cook, E. F., 1957, Geology of the Pine Valley Mountains, Utah: Utah Geol. and Mineralog. Survey Bull. 58, 111 p.

———1960, Geologic atlas of Utah, Washington County: Utah Geol. and Mineralog. Survey Bull. 70, 124 p.

Dibblee, T. W., Jr., 1967, Areal geology of the western Mojave Desert, California: U.S. Geol. Survey Prof. Paper 522, 153 p.

Gillespie, J. B., and Bentley, C. B., 1971, Geohydrology of Hualapai and Sacramento Valleys, Mohave County, Arizona: U.S. Geol. Survey Water-Supply Paper 1899–H, p. H1–H37.

Gregory, H. E., 1950, Geology of eastern Iron County, Utah: Utah Geol. and Mineralog. Survey Bull. 37, 153 p.

Hall, W. E., and Stephens, H. G., 1963, Economic geology of the Panamint Butte quadrangle and Modoc district, Inyo County, California: California Div. Mines and Geology, Spec. Rept. 73, 39 p.

Hamblin, W. K., 1970, Structure of the western Grand Canyon region, *in* Hamblin, W. K., and Best, M. G., eds., Guidebook to the geology of Utah: Utah Geol. Soc. no. 23, p. 3–19.

Hewett, D. F., 1931, Geology and ore deposits of the Goodsprings quadrangle, Nevada: U.S. Geol. Survey Prof. Paper 162, 172 p.

Heylmun, E. B., ed., 1963, Guidebook to the geology of southwestern Utah: Intermountain Assoc. Petroleum Geologists, 12th Annual Field Conference, Salt Lake City, Utah, 232 p.

Hintze, L. F., 1963, Geologic map of southwestern Utah: Utah Geol. and Mineralog. Survey, scale 1:250,000.

Jahns, R. H., ed., 1954, Geology of southern California: California Div. Mines and Geology Bull. 170.

Jennings, C. W., 1958, Geologic map of California, Death Valley sheet, Olaf P. Jenkins edition: California Div. Mines and Geology, scale 1:250,000.

———1961, Geologic map of California, Kingman sheet, Olaf P. Jenkins edition: California Div. Mines and Geology, scale 1:250,000.

———1972, Geologic map of California, south half (preliminary): California Div. Mines and Geology, scale 1:750,000.

Jennings, C. W., Burnett, J. L., and Troxel, B. W., 1962, Geologic map of California, Trona sheet, Olaf P. Jenkins edition: California Div. Mines and Geology, scale 1:250,000.

Kupfer, D. H., 1960, Thrust faulting and chaos structure, Silurian Hills, San Bernardino County, California: Geol. Soc. America Bull., v. 71, p. 181–214.

Liggett, M. A., and Childs, J. F., 1973, Evidence of a major fault zone along the California-Nevada state line 35°30′–36°30′ north latitude: Argus Exploration Company, NASA Rept. Inv., NASA–CR–133140, E73–10773, 13 p.

Malmberg, G. T., 1967, Hydrology of the valley-fill and carbonate-rock reservoirs, Pahrump Valley, Nevada-California: U.S. Geol. Survey Water-Supply Paper 1832, 47 p.

Maxey, G. B., and Jameson, C. H., 1948, Geology and water resources of Las Vegas, Pahrump, and Indian Spring Valleys, Clark and Nye Counties, Nevada: Nevada Water Resources Bull. 5, 121 p.

McAllister, J. F., 1952, Rocks and structure of the Quartz Spring area, northern Panamint Range, California: California Div. Mines and Geology Spec. Rept. 25, 38 p.

———1955, Geology of mineral deposits in the Ubehebe Peak quadrangle, Inyo County, California: California Div. Mines and Geology Spec. Rept. 42, 63 p.

———1956, Geology of the Ubehebe Peak quadrangle, California: U.S. Geol. Survey Map GQ–95, scale 1:62,500.

———1970, Geology of the Furnace Creek borate area, Death Valley, Inyo County, California: California Div. Mines and Geology Map Sheet 14, scale 1:24,000.

McKee, E. H., 1968, Geology of the Magruder Mountain area, Nevada-California: U.S. Geol. Survey Bull. 1251–H, 40 p.

Noble, D. C., 1968, Kane Springs Wash volcanic center, Lincoln County, Nevada, *in* Eckel, E. B., ed., Nevada Test Site: Geol. Soc. America Mem. 110, p. 109–116.

Norman, L. A., Jr., and Stewart, R. M., 1951, Mines and mineral resources of Inyo County: California Jour. Mines and Geology, v. 47, no. 1, p. 17–223.

Rogers, T. H., 1967, Geologic map of California, San Bernardino sheet, Olaf P. Jenkins edition: California Div. Mines and Geology, scale 1:250,000.

Ross, D. C., 1965, Geology of the Independence quadrangle, Inyo County, California: U.S. Geol. Survey Bull. 1181–0, 64 p.

Schrader, F. C., 1909, Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave Co., Arizona: U.S. Geol. Survey Bull. 397, 226 p.

Smith, A. R., 1964, Geologic map of California, Bakersfield sheet, Olaf P. Jenkins edition: California Div. Mines and Geology, scale 1:250,000.

Smith, G. I., Troxel, B. W., Gray, C. H., and von Huene, Roland, 1968, Geologic reconnaissance of the Slate Range, San Bernardino and Inyo Counties, California: California Div. Mines and Geology Spec. Rept. 96, 33 p.

Stokes, W. L., and Heylmun, E. B., 1963, Tectonic history of southwestern Utah, *in* Heylmun, E. B., ed., Guidebook to the geology of southwestern Utah: Intermountain Assoc. Petroleum Geologists Guidebook 12, p. 19–25.

Strand, R. G., 1967, Geologic map of California, Mariposa sheet, Olaf P. Jenkins edition: California Div. Mines and Geology, scale 1:250,000.

Threet, R. L., 1963, Structure of the Colorado Plateau margin near Cedar City, Utah, *in* Heylmun, E. B., ed., Guidebook to the geology of southwestern Utah: Intermountain Assoc. Petroleum Geologists Guidebook 12, p. 104–117.

Tschanz, C. M., and Pampeyan, E. H., 1970, Geology and mineral deposits of Lincoln County, Nevada: Nevada Bur. Mines and Geology Bull. 73, 187 p.

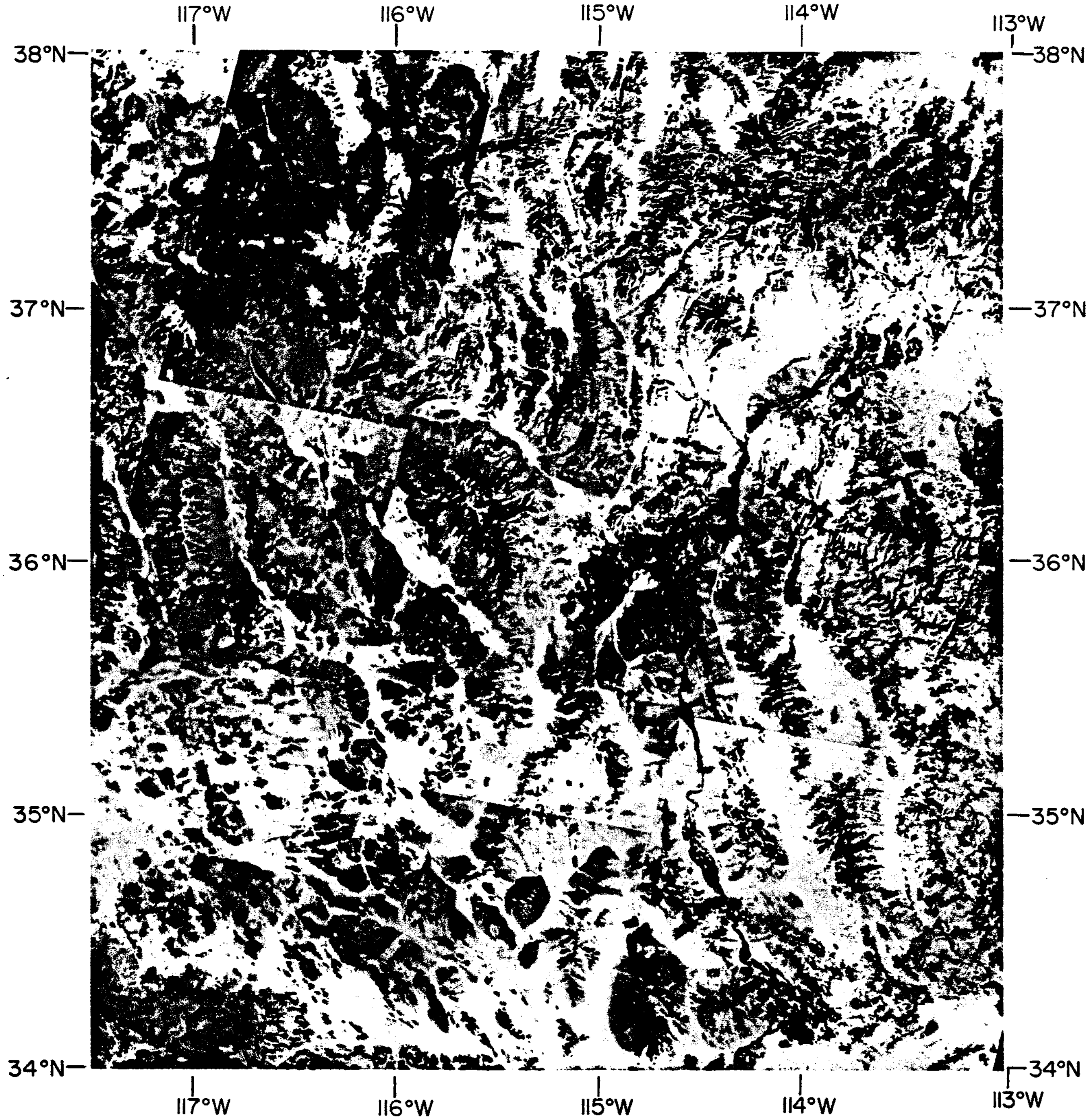


FIGURE 2.—False-color mosaic of 11 Landsat-1 MSS composites covering the area of study outlined in figure 1. Identification numbers for the frames used in this mosaic are shown in figure 3 (p. 255). See text for discussion of the MSS bands and printing filters used in producing the composites.

LIGGETT AND CHILDS

Mohave Cty

GEOEXPLORERS INTERNATIONAL, INC.
5701 EAST EVANS AVENUE. DENVER, COLORADO 80222. USA. TEL 303-759-2746

DR. JAN KRASON
PRESIDENT

GEOLOGY, ENERGY AND MINERAL RESOURCES ASSESSMENT OF THE BILL WILLIAMS AREA, ARIZONA

BY

A. WODZICKI, JAN KRASON AND SUSAN K. CRUVER

GEOEXPLORERS INTERNATIONAL, INC.

5701 East Evans Avenue
Denver, Colorado 80222
Telephone 303-759-2746

Prepared for:

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

December 31, 1982

Geo-Scientific, Professional and Engineering Services

4. **Dobbins Claims**

Other names: Jolly Roger

Location: 33°56'43"N, 113°55'23"W
Sec. 15, T7N, R16W

Commodity: Mn

Ore Materials: Pyrolusite, psilomelane.

Deposit Description:
Small N65°E striking, NW dipping tabular shaped ore body.

Geology: Mineralization along a shear zone in Tertiary andesite. Manganese minerals cement the fault breccia and replace andesite fragments.

Production: Yes

References: USGS CRIB Mineral Resources File 12, Record 2774, p. 7073-7075.

6. **Little Butte Copper Mine**

Other Names: Arizona Pride

Location: 33°57'50"N, 114°03'15"W
Sec. 7 and 8, T7N, R17W

Commodities: Au, (major product); Cu, Ag (minor product); Fe, Mn.

Ore Materials: Chrysocolla, malachite, hematite, specularite.

Deposit description and geology:
Small, irregularly shaped deposit is in limestone and granite intruded by Tertiary diabase. Underground workings.

Production: Yes, 5800 tons through 1955, 0.45 oz/T Au, 0.16 oz/T Ag, 2% Cu.

Reference: USGS CRIB Mineral Resources File 12, Record 2776, p. 7078-7080; Keith, 1978

Note: Latitude and longitude (24°57'18", 114°18'42"W) given in USGS CRIB is obviously wrong, location given is PLS location given in the CRIB and confirmed by geology and symbol on topographic map.

7. **Blue Slate Mine**

Location: 33°57'54"N, 114°04'08"W
NE 1/4 sec. 7, T7N, R17W

Commoditites: Au (major product); Cu, Ag (minor products), Fe (occurrence).

Ore Materials: Gold, copper stain, hematite, limonite.

Deposit Description:
Vein is a maximum of 2 feet wide and strikes N20°W, dipping NE. Workings: 2 shafts and open cuts.

Geology: Deposit is along a fault zone in Cretaceous metamorphosed shales intruded by Tertiary diorite porphyry.

Production: 130 tons of ore containing 3% Cu, 1 oz Au/T and traces of Ag were removed.

References: USGS CRIB Mineral Resources File 12, Record 2777, p. 7081-7083, Keith, 1978.

intersection with thrust fault which separates marble from underlying metamorphic rocks. Some mineralization is also present along the joint planes in amphibole schist.

Production: Few tens of tons.

References: USGS CRIB Mineral Resources File 12, Record 2799, p. 7144-7146, Keith, 1978.

18. **Clara Mine**

Location: 34°09'48"N, 113°47'36"W
Sec. 20, 26 and 35, T10N, R15W

Commodities: Cu (major product); Au, Ag (minor products); Fe (occurrence).

Ore materials: Chrysocolla, chalcocite, iron staining, leaf gold and jasper.

Deposit description:
Small, irregular and lensing shaped replacement. Workings: consist of a short adit tunnel and adit with a short winze at the end.

Geology: Mineralization in Precambrian granite and gneiss, and in Paleozoic limestone, associated with Tertiary volcanic tuff.

Production: 1911-1940, 50,000 tons at 4.7% Cu, minor Ag, Au.

References: USGS CRIB Mineral Resources File 12, record 2808, p. 7166-7168; Keith, 1978.

19. **Clara-Swansea Mine**

Synonym name: Signal, Copper Prince

Location: 34°10'03"N, 113°50'34"W
Sec. 29, 32, T10N, R15W

Commodities: Cu (major product); Ag, Au (minor products); Fe (occurrence).

Ore materials: Chalcopyrite, bornite, pyrite, specularite, and hematite.

Deposit description:
Small, irregularly shaped replacement. Workings: underground.

Geology: Mineralization in Precambrian gneiss and in fault block of folded Paleozoic limestone.

Production: 352,000 tons of ore at 3% Cu, 0.09 oz Ag/T, and minor Au.

References: USGS CRIB Mineral Resources File 12, record 2809, p. 7169-7170; Keith, 1978.

20. **Mystery Hill**

Location: Sec. 29, T10N, R15W.

Commodities: Ag, F, Pb, Au.

Ore Materials: Silver, fluorspar, lead and gold.

Deposit description:
Small vein deposit. Workings: underground.

Production: Yes, small amount.

References: USGS CRIB Mineral Resources File 12, record 2810, p. 7172-7173.

21. **Mineral Hill Mine**

Other names: Continental
Location: SE 1/4 sec. 2, NE 1/4 and E cen. sec. 10, NW 1/4 sec. 11, T10N, R17W.
Commodities: Cu (major product); Ag, Au, Fe (minor products); Be (occurrence).
Ore materials: Chrysocolla, specularite, azurite, and malachite.
Deposit Description:
Small irregular shaped hydrothermal replacement. Workings: underground, short adits, a raise, numerous pits.
Geology: Mineralization in folded and faulted Paleozoic Limestone and limey shale ovelying Precambrian gneiss.
Production: Worked sporadically from early 1900's through 1970, averageing 1.7% Cu, minor Au and Ag.
References: USGS CRIB Mineral Resources File 12, Record 2811, p. 7174-7176; Keith, 1978.

23. **Iron King Mine**
Other name: War Eagle
Location: 34°13'16"N, 113°58'47"W
Sec.12, T10N, R17W
Commodities: Mn (major product); Ba, Fe (occurrence).
Ore materials: Mn oxides, barite, hematite and Fe-oxide.
Deposit description:
Small N45°W-trending, SW dipping, blow outs shaped replacement. Workings: underground, short tunnels and shallow shaft.
Geology: Mineralization in Precambrian granite gneiss associated with Tertiary basalt flows.
Production: Yes, small amount.
References: USGS CRIB Mineral Resources File 12, Record 2813, p. 7179-7181.

24. **Carnation Mine**
Other names: Empire, Gray Eagle
Location: 34°11'56"N, 114°8'45"W
Sec. 16, 17 and 21, T10N, R18W
Commodities: Cu, Au (major products); Ag (minor product).
Ore materials: Copper carbonate, siderite, and hematite.
Deposit description:
Small, irregular lense shaped vein. Workings: underground.
Geology: Mineralization in Precambrian amphibolitic schists associated with Tertiary basalt flows.
Production: 8,000 tons.
References: USGS CRIB Mineral Resources File 12, Record 2814, p. 7182-7184; Keith, 1978.

25. **Wardwell and Osbourne Mine**
Other name: Mammon Copper.
Location: 34°09'38"N, 114°07'10"W
Sec. 34, T10N, R18W
Commodities: Cu (major product); Au, Ag, Fe (minor products).
Ore Materials: Hematite, chrysocolla and malachite.

Deposit description:
Small, irregular shaped vein/replacement. Workings: underground, including about 2000 feet of drifts, together with some winzes, raises and stopes.

Geology: Mineralization in carboniferous limestone associated with Tertiary intrusive masses and basalt deposits controlled by fracturing and bedding.

Production: Yes, small amount.

References: USGS CRIB Mineral Resources File 12, Record 2818, p. 7194-7196; Keith, 1978.

29. **Capiland Mine**

Other name: Capilano Mine

Location: 34°11'01"N, 114°12'4"W, Sec. 26, T10N, R19W.

Commodities: Au, Cu (major products); Ag (minor product)

Ore Materials: Chrysocolla, malachite, specularite and gold.

Deposit description:
Small, irregular shaped deposit in a vein/shear zone. Workings: property has been explored by a shallow shaft and several surface cuts.

Geology: Mineralization in Paleozoic limestone and in Precambrian schistose quartzite associated with Tertiary basalt flow.

Production: Limited production.

References: USGS CRIB Mineral Resources File 12, Record 2819, p. 7197-7199; Keith, 1978.

30. **Rio Vista Mine**

Other names: Northside, Quartz King

Location: 34°10'39"N, 114°11'59"W, Sec. 26, T10N, R19W

Commodities: Cu, Au (major products); Ag (minor product).

Ore materials: Chrysocolla, malachite, hematite and specularite.

Deposit description:
Small NS-trending, vertical dipping, irregular, lenticular shaped vein in a shear zone. Workings: underground.

Geology: Mineralization in Paleozoic metamorphosed limestone, and in Precambrian schistose quartzite associated with Tertiary basalt.

Production: 200 tons at 5-8% Cu, 0.4-0.5 oz Au/T.

References: USGS CRIB Mineral Resources File 12, Record 2820, p. 7200-7202; Keith, 1978.

31. **New Planet Mine**

Other names: Planet Copper Mine, Planet Mine

Location: 34°14'38"N, 113°58'11"W

Commodities: Cu, Au, Ag, Fe.

Ore Materials: Hematite, chrysocolla, gold, silver, bornite, chalcopyrite, pyrite, limonite, azurite and malachite.

Deposit Description:
Small, irregular shaped replacement and veins along fault zone. Workings: underground.

909, p. 2422-2424.

39. **Arizona Manganese Prospect**
Location: 34°27'14"N, 114°19'46"W, Sec. 23, T13N, R20W.
Commodities: Mn (major product); Fe (minor product).
Ore materials: Psilomelane and pyrolusite.
Deposit description:
Small, NW-trending deposits dipping to the NE, located in veins and brecciated zones. Workings: surface.
Geology: Mineralization in Precambrian gneiss, diorite and granite associated with Late Tertiary basalt and sandstone.
Production: Yes, small amount.
References: USGS, 1979, CRIB, Mineral Resources File 12, Record 913, p. 2432-2434.

40. **Dutch Flat Mine**
Other Name: Kampf.
Location: 34°31'55"N, 114°10'33"W, Sec. 19, 20, 29 and 30, T14N, R18W.
Commodities: W, Au, (major products); Ag, Cu, Pb (minor products).
Ore Materials: Wolframite, galena and specularite.
Deposit description:
Small, N28°W-trending, ore body dipping 60°SW, stringers, short pods, and lense shaped vein. Workings: underground.
Geology: Mineralization in Precambrian gneiss and schist associated with granite and basic felsitic dikes.
Production: Yes, small amount.
References: USGS, 1979, CRIB Mineral Resources File 12, Record 916, p. 2440-2442; Wilson, 1941.

41. **Chemehuevis Placers**
Other name: Calizona
Location: 34°35'01"N, 114°17'47"W, Sec. 26, 27, and 28, T14N, R19W, T15N, R20W.
Commodity: Au
Ore Material: Gold
Deposit description:
Small, placer deposits. Workings: Surface.
Geology: Conglomerate, fanglomerate and gravels are present.
Production: Yes, small amount.
References: USGS, 1979, CRIB Mineral Resources File 12, Record 917, p. 2443-2445.

42. **Yucca Mine**
Location: 34°38'09"N, 114°22'28'W, Sec. 17, T15N, R20W.
Commodity: Mn
Ore materials: Wad-like oxides, psilomelane and pyrolusite.
Deposit description:
Small, NE-trending, dipping 8°NW, lenses in

bedded, shear zone. Workings: Surface and underground.

Geology: Mineralization in Tertiary sandstone and andesite flows.

Production: Yes, small amount.

References: USGS, 1979, CRIB Mineral Resources File 12, Record 918, p. 2446-2448.

52. **Happy Day No. 3 Mine**

Other names: Black Mule, Barite No. 3.

Location: Sec. 31, T7N, R17W.

Commodities: Ba, F.

Ore Material: Barite and fluorite.

Deposit description:

Irregular lensing barite and fluorite in fault veins and breccia zones. Workings: Open cut operations.

Geology: Irregular lensing barite and fluorite in fault veins and breccia zones in rhyolitic volcanics, interbedded with metamorphosed Mesozoic sediments.

Production: 100 tons in 1938, 80% $BaSO_4$ and 3.5% CaF_2.

References: McCrory and O'Haire, 1965, Keith, 1978.

84. **Chemehuevis District Placers**

Other names: Gold Wing District, includes Calizona Placer channel, Fisher Diggings, Silver Creek, the "49", Chief, and Prentice Gulch properties.

Location: T14N, R20W; T15N, R20W and T15N, 19W.

Commodities: Au, rare earths.

Ore Materials: Auriferous gravels, detrital monazite.

Deposit description:

Placer gold deposits.

Geology: Auriferous gravel is in conglomerate or fanglomerate. The source is thought to be gold-bearing quartz veins in Precambrian schist. Placer deposts were worked along the Colorado River, in the Red Hills area and in Dutch and Printer Gulches.

Production: Yes, total between 100 and 1000 troy ounces.

References: Johnson, 1972; Arizona Bureau of Mines, 1969.

85. **Santa Maria District Placers**

Other names: Planet District Placers

Location: T10N, R15W; T10N, R16W.

Commodity: Au

Deposit description:

Placer.

Geology: Some lode gold ores were known to occur in the Planet district; presumably they are the source of the gold.

Production: 12 ounces of gold and 12 ounces of silver.

References: Johnson, 1972; Keith, 1978.

95. **Golden Ray Mine Group**

Location: Sec. 24, T10N, R19W.

Commodities: Au, Cu, Ag.

Deposit description:
Irregular, tabular, replacement bodies, some vein and breccia fillings of hematite cut by stringers and disseminations of copper carbonates. Reported chalcopyrite and bornite at depth.
Geology: Mineralization in Precambrian gneiss and schist and Paleozoic limestone overlying the metamorphic core complex along a probable thrust fault zone.
Production: Worked sporadically from early 1900's to 1924.
Reference: Keith, 1978.

111. **Arizona Midway Mine**
Location: S. sec. 1, T8N, R16W.
Commodities: Cu, Au, Ag, marble.
Deposit description:
Spotty, oxidized, copper mineralization in Precambrian schist. Some high grade copper pods. Limited exposures of varicolored marble bounded by schist.
Geology: Mineralization in Mesozoic schist containing limestone bands.
Production: Limited production around 1917.
References: Keith, 1978.

120. **Battleship Copper Mine**
Location: NW 1/4 sec. 3, T8N, R15W.
Commodities: Cu, Ag, Fe.
Ore materials: Oxidized copper and sulfides, hematite.
Deposit description:
Spotty oxidized copper mineralization with minor sulfides in irregular, hematite-rich, replacement lenses.
Geology: Mineralization in flat-lying shale beds of metamorphosed Mesozoic sediments, overlying metamorphic core complex.
Production: Limited production in early 1900's.
Reference: Keith, 1978.

136. **Black Chief Mine**
Location: Sec. 24, T7N, R18W.
Commodities: Mn, Fe.
Ore materials: Manganese and iron oxides.
Deposit description:
Irregular, lenticular masses and strands of manganese oxides mixed with iron oxides and calcite in breccia.
Geology: Mineralization in breccia, along a fracture vein in metamorphosed Mesozoic sedimentary rocks.
Production: Small amount of high grade ore during WWII, and some 2000 tons mined in 1953.
Reference: Keith, 1978.

137. **Black Mountain Mine Group:**
Location: Sec. 34, T8N, R17W.
Commodities: Ba, F, Cu.

147. **Cindy Mine**
Location: W central sec. 19, T7N, R17W.
Commodities: Mn.
Ore materials: Psilomelane and pyrolusite.
Deposit description:
Lenses of psilomelane and pyrolusite mixed with siliceous limestone and calcite.
Geology: Mineralization in bedding plane fracture in metamorphosed Mesozoic limestone.
Production: Worked in 1953, producing 144 tons of sorted 25% Mn.
Reference: Keith, 1978.

148. **Coronation Mine Group**
Other names: Mystery Hill, Blue Moon, Copper Hill.
Location: Sec. 31, T7N, R17W.
Commodities: Cu, Ag, Au.
Ore material: Unknown.
Deposit description:
Spotty copper, silver and gold mineralization, largely oxidized in irregular qauartz veins.
Geology: Mineralization in quartz veins along fractures in Precambrian gneiss.
Production: Worked in late 1940's and early 1950's, producing 115 tons of ore averaging about 1.8% Cu, 0.18 oz. Ag/T and 0.07 oz. Au/T.
Reference: Keith, 1978.

149. **Heart's Desire Mine**
Other names: Jackson Copper, Copper King.
Location: SE 1/4 sec. 13, T7N, R18W.
Commodities: Cu, Pb, Ag, Au.
Ore Materials: Oxidized copper, lead, silver and gold mineralization.
Deposit description:
Spotty lensing, oxidized copper, lead, silver, and gold mineralization with sulfides at depth, along a fault zone at intersections with cross fractures.
Geology: Mineralization in metamorphosed Mesozoic schist, with interbedded andesite and cut by diorite dikes.
Production: Worked from early 1900's to about 1914, producing some 200 tons of ore averaging about 7% Cu, 2% Pb, 3 oz. Ag/T and 1.6 oz Au/T.
Reference: Keith, 1978.

150. **Linda K Mine**
Location: SE 1/4 sec. 14, T7N, R16W.
Commodities: Mn
Ore materials: Pyrolusite, psilomelane, and manganite.
Deposit description:
Pyrolusite, psilomelane, and manganite with calcite and breccia in seams and veinlets in fracture zones.
Geology: Mineralized fracture zones in Tertiary andesitic volcanics covering Tertiary granite.
Production: 30 tons in 1918, 1500-2000 tons in 1953-1954.
Reference: Keith, 1978.

Reference: Keith, 1978.

157. **Lake Havasu Sand and Gravel**
Location: T 13N, R20W.
Commodities: Sand and gravel.
Production: 1,553,000 tons as of 1967.
Reference: Arizona Bureau of Mines, 1969.

159. **Plomosa Mining District**
Location: T8N, R18W
Commodities: Au, Ag, Cu, Pb, Zn, Mn, Ba, Fe, bentonite.
Ore materials: Gold, partly oxidized copper minerals, lead and zinc minerals, iron and manganese oxides, barite, fluorite.
Deposit description:
Spotty, partly oxidized copper and gold mineralization with minor lead and zinc, with quartz, iron and manganese oxides in irregular fault and fracture veins, in metamorphosed Mesozoic sediments, shale, sandstone, conglomerate, and limestone; Precambrian metamorphics; and Cretaceous or Tertiary volcanics, with diorite and granite intrusions. Manganese oxides occur also in irregular lenticular bodies and veinlets with variable amounts of iron oxides, calcite, barite and gypsum. Fracture and breccia zones in Cretaceous or Tertiary andesitic volcanics. Barite and fluorite also occur in veins along faults and fractures in Cretaceous or Tertiary volcanic flows and agglomerates. Copper, lead and zinc mineralization occurs with silver and gold, associated iron and manganese, in faulted Paleozoic limestone blocks and irregular veins in Cretaceous or Tertiary andesite volcanics, cut by quartz monzonite intrusives. Gold and silver mineralization in irregular veins along fractures and fault zones associated with quartz stringers and Laramide diorite and granite porphyry dikes in Mesozoic schist. Bentonitic clay occurs in probable lake bed sediment.
Production: 26,000 tons of ore produced in the district (which includes areas outside of the Bill Williams GRA). The ore contained about 26,000 tons of copper, 344 tons of lead, 65 tons of zinc, 7,000 ounces of gold, and 127,400 ounces of silver. Some 9000 tons of manganese ore, 2700 tons of barite ore, and a small amount of bentonite production.
Reference: Keith, 1978.
Note: District boundary line is approximate.

160. **Santa Maria Mining District**
Location: T9N, R15W, T11N, R17W.
Commodities: Cu, Fe, Mn, Au, Ag.
Ore materials: Copper oxides and sulfides, hematite, manganese oxides, gold.
Deposit description:

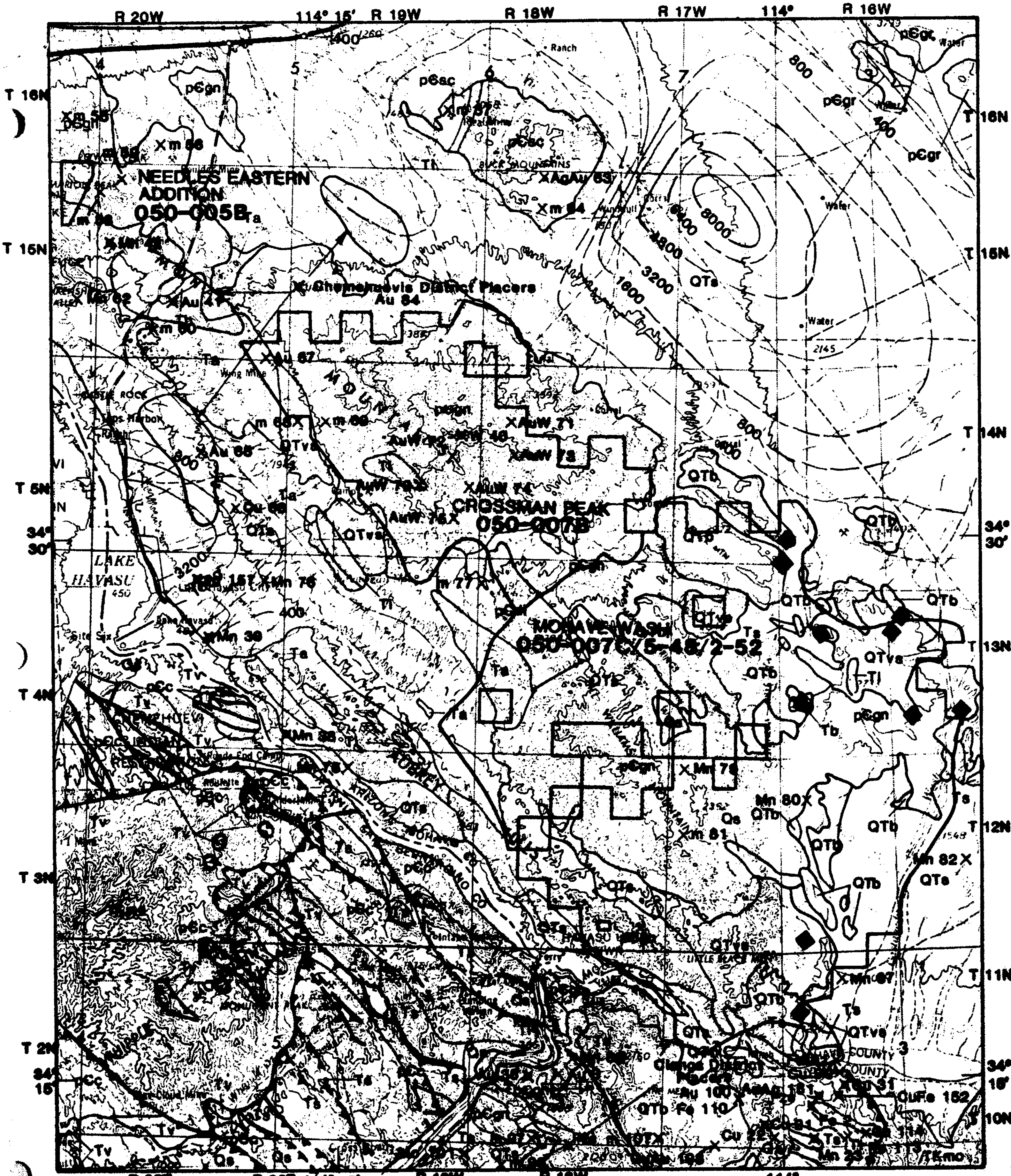


FIG. 3 GEOLOGIC, ENERGY AND MINERAL RESOURCES MAP OF THE HAVASU SUB-AREA, ARIZONA

Scale
1 : 250.000

reference to:
North Star Group (file)
Strongbow Group (file)
Moss Mine (file)
Bald Eagle Gold Mining (file)
Expansion Group (card)
Golden Era Properties (card)
Gold Era Group Club (card)
Highland Chief Group (card)
Iowa Group of Mines (card)
Krauss Properties (card)
Miller Group (card)
Monarch Property (card)
Mountain Beauty (card)
OK Mine Group (card)
San Diego Mine (card)
Sunlight (card)
Tom Reed Gold Road (card)
Tragedy Group (card)
Union Pass Group (card)

BLACK MOUNTAINS SOUTH G-E-M RESOURCES AREA

(GRA NO. AZ-06)

TECHNICAL REPORT

Contract YA-553-RFP2-1054

Prepared By

Great Basin GEM Joint Venture
251 Ralston Street
Reno, Nevada 89503

For

Bureau of Land Management
Denver Service Center
Building 50, Mailroom
Denver Federal Center
Denver, Colorado 80225

Final Draft

November 1, 1982

In the Union Pass district area numerous prospects occur in a northwest trending belt from Secret Pass Wash in the southeast to several miles beyond Sugarloaf Mountain in the north. These prospects are mainly located along the trend of gold producing veins.

An unknown shaft and several drill holes in Tertiary volcanics are found in Secs. 9, 10, 14, 15, 16, 17 and 23 of T 17 N, R 19 W. This is reportedly the "Tom Kew" prospect which is in volcanics showing silicification and other alteration assemblages. There is a long arcuate area here of alteration of apparently andesitic volcanics adjacent to and beneath the capping basalt flows to the immediate east. This area was field checked.

Another area of alteration spotted from the air and field verified occurs in Sections 35 and 36 of T 17 N, R 19 W and Sections 19 and 20 of T 16-1/2 N, R 19 W. This alteration area is the site of a previous clay producer and includes considerable silicification.

The Gold Trail mine in Sec. 10, T 19 N, R 19 W was field checked and consists of a northwest trending vein along a major near vertical normal fault which juxtaposes andesites on the east against rhyolitic tuff units on the west. The vein attains a width of three to five feet near the mine shaft and consists of fractured and brecciated andesites with quartz and iron oxides. The host rock is

USGS OF 81-503

THE ORIGIN OF A MIOCENE BASALT-RHYOLITE SUITE, SOUTHERN BASIN AND RANGE PROVINCE, WESTERN ARIZONA

Neil Suneson, Geothermal Exploration Division, Chevron Resources Company, P. O. Box 3722, San Francisco, CA 94119
Ivo Lucchitta, Branch of Central Environmental Geology, U. S. Geological Survey, 2255 No. Gemini Dr., Flagstaff, AZ 86001

Miocene volcanic rocks in the Castaneda Hills and northwestern part of the Artillery Peak 15' quadrangles, west-central Arizona, are interbedded with continental clastic sedimentary rocks, minor limestone, gravity glide blocks of Precambrian(?) and Paleozoic(?) rocks, and monolithologic megabreccia. The units we have mapped correlate with the Artillery and Chapin Wash Formations of Lasky and Webber (1949). In particular, basalt in their Artillery Formation is equivalent to our older basalts. Their Cobwebb Basalt, basalt in the Sandtrap Conglomerate, and Pleistocene(?) basalts are equivalent to our mesa-forming basalts.

The volcanic suite is strongly bimodal; rocks that have 55 to 71 weight percent SiO_2 are absent. Five volcanic units can be distinguished on the basis of age, geomorphic position, and petrography: the older basalts (18.7 and 16.5 m.y.), quartz-bearing basalts (13.7 and 12.4 m.y.), rhyolite lavas and tuffs (15.1 to 10.3 m.y.), mesa-forming basalts (13.1 to 19.2 m.y.), and megacryst-bearing basalts (3.6 to 6.8 m.y.). The basalts contain groundmass olivine and titanaugite phenocrysts and are alkali-olivine basalts. Most of the rhyolites contain more than 75 weight percent SiO_2.

The initial Sr isotopic composition of the basalts is: older basalts, 0.7077; quarts-bearing basalts, 0.7034; mesa-forming basalts, 0.7062; and megacryst-bearing basalts, 0.7035 and 0.7038. This evidence suggests that some of the basalts ($^{87}Sr/^{86}Sr_i$ = 0.703 to 0.704) are partial melts of upper mantle material. The chemical composition of some of the megacrysts in the megacryst-bearing basalts suggests a high-pressure mantle origin (4.4 to 15.8 percent Ca-Tsch and Mg/Mg+Fe* = 69.8 to 88.1 in clinopyroxenes, Al_2O_3 = 3.14 to 7.76 percent in titanomagnetites, presence of ferrian pleonaste). Whole-rock Mg/Mg+Fe* = 40.6 to 56.6 and the presence of phenocrysts in these basalts indicates crystal fractionation before eruption. Other basalts that have $>{}^{87}Sr/{}^{86}Sr_i$ 0.705 probably were derived from previously depleted lower crustal granulites. A very crude positive correlation between $^{87}Sr/^{86}Sr_i$ versus Sr and K/Rb and an inverse correlation between $^{87}Sr/^{86}Sr_i$ and Rb/Sr indicate that the high ^{87}Sr basalts are not contaminated with older crustal material. Partial melting from an isotopically vertically stratified upper mantle is also unsupported; the high-silica (quartz-bearing) basalts have low $^{87}Sr/^{86}Sr_i$.

The rhyolites have initial Sr isotopic ratios of 0.7093 and 0.7141. These ratios are higher than those of the basalts and indicate that the rhyolites were not differentiated from the basalts. Partial melting of 1.3 b.y.-old lower crustal material with Rb/Sr = 0.10 to 0.19 satisfactorily explains the isotopic ratios of the rhyolites. Granulite, which may constitute the lower crust in this part of Arizona, has Rb/Sr ratios similar to those required to produce the rhyolites.

The quartz-bearing basalts were derived from the mantle. The low (0.7034) $^{87}Sr_i$ precludes contamination by old crustal material, and high FeO and TiO_2 content indicate that dilution by Tertiary rhyolite did not occur. Like other quartz-bearing basalts in the Basin and Range Province, those in the Castaneda Hills area contain olivine. The quartz may be a high-pressure phenocryst (Nicholls and others, 1971), whereas the olivine crystallized at lower pressures.

Some of the rhyolites contain high (7 to 9 percent) K_2O and low Na_2O (0.8 to 2 percent). Harker diagrams indicate an apparent direct substitution of K for Na probably occurred during cooling and devitrification in the presence of an alkali-rich fluid. The groundmass feldspar concentrated K compared to the glass from which they crystallized.

In summary, the Miocene volcanic rocks in the Castaneda Hills area were generated by partial melting of upper mantle peridotite and partial to extensive melting of old, variably depleted lower crustal granulite. These melting events occurred over a relatively brief (19 to 7 m.y.) time interval. The production of basaltic and rhyolitic magma from the Earth's crust and mantle requires extremely heterogenous source regions. The mantle and crust have obvious compositional differences. In western Arizona, the ower crust also is compositionally heterogeneous due to varying degrees of epletion of the lower melting fraction, possibly during the Laramide oro-eny. The eruption of crustal-derived basalt and rhyolite at the same time nd in the same place suggests that compositional differences within the ower crust are remarkably abrupt. An additional factor affecting the egree of partial melting in the lower crust may be thermal inhomogeneities inherited from previous magmatic events. This would enable "warm", previ-usly depleted granulite to produce basalts during the same Miocene thermal event in which "cool", undepleted granulite is producing rhyolite.

The bimodal volcanism and associated tectonism in the Castaneda Hills area represent a heating and distension event that affected the entire Basin and Range Province in the Miocene. In some areas, extensional deformation was manifested as low-angle listric faults within a thin suprastructure. Elsewhere, more "typical" and slightly younger high-angle normal faults penetrated to greater depths. The Basin and Range orogeny probably was caused by the complex interaction of inter- or back-arc spreading with the termination of subduction and lengthening of the San Andreas transform system. The detailed history is probably more complex because of crustal compositional and thermal inhomogeneities inherited from Paleozoic, Mesozoic, Laramide, and early- and mid-Tertiary deformational and magmatic events.

References Cited:

Lasky, S. G., and Webber, B. N. 1949, Manganese resources of the Artillery Mountains region, Mohave County, Arizona: U. S. Geol. Survey Bull. 961, 86p.

Nicholls, J., Carmichael, I.S.E., and Stormer, J.C., Jr., 1971, Silica activity and P total in igneous rocks: Contr. Min. and Pet., v. 33, p. 1-20.

USGS OF 81-503

OBSERVATIONS AND SPECULATIONS REGARDING THE RELATIONS AND ORIGINS OF MYLONITIC GNEISS AND ASSOCIATED DETACHMENT FAULTS NEAR THE COLORADO PLATEAU BOUNDARY IN WESTERN ARIZONA

Lucchitta, Ivo, U. S. Geological Survey, 2255 North Gemini Drive, Flagstaff, Arizona 86001; and Suneson, Neil, Geothermal Division, Chevron Resources Company, P. O. Box 3722, San Francisco, CA 94119

One of the most obdurate problems confronting students of the mylonitic-gneiss complexes and associated detached upper plates that are unmetamorphosed but highly distended, has been the spatial and temporal relation between mylonitization, detachment faulting, and extension. A common view is that the mylonization is late Cretaceous to Oligocene, although a few isotopic ages are as young as Miocene, whereas the detachment faulting is middle to late Miocene. This hypothesis is based on the abrupt break in metamorphic grade at the detachment faults, the absence of mylonization in the upper plate, the common early Tertiary isotopic ages on the mylonite gneiss, and the truncation of mylonite structures by the detachment faults. An inescapable corollary of this hypothesis is that the upper plates are gravity-glide masses, and that these masses slid along surfaces--the detachment faults--exactly coincident with some older but poorly understood surfaces truncating the mylonite gneisses.

Thus Shackleford (1980) in his excellent treatment of Tertiary denudation faulting in the Rawhide Mountains of Arizona, concluded that (1) The autochthonous mylonitic gneisses reflect a tectonic event separate and older than that represented by the Rawhide (detachment) Fault (RF), and (2) Denudation occurred through northeast-directed gravity gliding of upper plate allochthonous rocks. Our observations and speculations are based on several years of detailed mapping of upper plate rocks in an area directly north of that mapped by Shackleford and extending toward the Colorado Plateau.

As mapped by Shackleford and by us, the RF dips gently to the north and northeast in the direction of the Colorado Plateau, which is as close as 40 km. If the upper plate is an allochthon that has moved northeast, how does the plate--and the associated RF--terminate in that direction? Assuming the Colorado Plateau is not allochthonous, the RF must end by shoaling, by offset along a transcurrent fault, or by decrease in displacement northeastward. We have searched for possible terminations of the upper plate, and have found none. The RF does not shoal upward. The Artillery fault, a possible condidate for a shoaling RF, is not a continuation of the RF, but is similar to other faults cutting upper plate rocks. Upper plate Tertiary rocks extend, in depositional contact, onto basement rocks of Colorado Plateau type northeast of the Aubrey Lineament, which separates terranes that differ greatly in morphology, structure, and types of rocks present (Lucchitta and Suneson, 1979). The Sandtrap Wash fault, which Shackleford suggested might terminate the upper plate, is part of the lineament. Our mapping shows that displacement along this fault decreases rapidly northward, where the fault merges with a north-trending normal fault that bounds the McCracken Mountains on the east. We have found no evidence of strike-slip displacement.

These relations indicate that the upper plate cannot have moved northeastward by gravity gliding. Possible alternatives are few. We suggest the following model:

The area mapped by us is near the northeast edge of a terrane marked by metamorphic-core complexes, extreme distension, and associated detachment faulting. Both metamorphism and faulting die out to the northeast, and the RF terminates in that direction by decrease in displacement, feathering into many breaks, and changing into a zone of distributive shear.

The upper plate is anchored at its northeast end to autochthonous basement rocks of Colorado Plateau type. To the southwest, in the vicinity of the Rawhide Mountains, it has been stretched and attenuated by listric faulting, but, fundamentally, it is in place. Thus, it is autochthonous or nearly so. The lower, gneissic, plate has moved southwestward, toward a culmination of the metamorphic-complex terrane, by non-brittle underflow. Hence, it is allochthonous. In such a tectonic regimen ("conveyor-belt tectonism" in our parlance), the upper plate merely goes along for the ride, being stretched and pulled apart in the process. Near the margins of the area affected by the process, this stretching is manifested mostly by brittle fracture (listric faults). In more central areas, where rock temperatures probably are more elevated, attenuation may occur by more ductile processes, as in the Big Maria Mountains (Hamilton, 1964).

The basal detachment fault (RF) is a locus of stress concentration that is difficult to visualize as following pre-existing structures, because it cuts the grain of such structures. We suspect that it is the locus of a change from brittle to non-brittle deformation, as suggested by Armstrong and Dick (1974), associated at the time of deformation with a steep temperature gradient.

Although the model can accomodate the interpretation that the formation of the mylonite gneiss was an early Tertiary event distinct from the late Tertiary detachment faulting, this interpretation does not explain the common and close spatial relation between basal detachment faults and mylonite gneiss, or the close coincidence in space of two kinematic events widely separated in time.

Another interpretation is that formation of the mylonite gneisses, movement on the RF, volcanism, deposition of Tertiary rocks, and listric faulting in the upper plate all are products of the same tectonic disturbance and are nearly of the same age. This interpretation requires that the early Tertiary K-Ar ages on the gneiss result from incomplete expulsion of argon during metamorphism of a Precambrian protolith, and thus are to be viewed as maximum ages.

We suggest that the area mapped by Shackleford and by us and containing the RF and associated upper plate is at the northeastern margin of the tectonic disturbance. To the southwest, heating, metamorphism, structural disturbance, and uplift were much greater. Little beside lower plate gneiss is present in that area today, but an indication of what once was present can be obtained from studying tectonic sheets that became interleaved with accumulating sediments of the upper plate. These sheets are gravity-glide blocks that came from the southwest. In places, they are stacked on top of each other, and collectively they form an inverted sequence consisting of greenschist-facies metasedimentary and metavolcanic rocks at the base, then quartzite and marble, and finally sheared and biotite-rich granitic rocks at the top. They represent the carapace at the top of the gneiss complexes, removed by progressive unroofing of the complexes as they were being uplifted. The sheets formed in response to uplift. The RF, in contrast, was formed by non-brittle underflow that contributed to the uplift.

In summary, we suggest that the lower plate mylonite gneiss and the RF are two expressions of an intense Tertiary (Miocene) thermal and deformational event that included volcanism, extension, listric and detachment faulting, basin formation, and the emplacement of imbricate gravity-glide masses that slid northeastward from an uplifted metamorphic-complex terrane. This disturbance was restricted to the area southwest of the Colorado Plateau, so that the degree of metamorphism, mylonitization, and displacement on the RF decrease northeast from the Rawhide Mountains. The origin of the RF is not related to gravity gliding, as Shackleford (1980) suggested, but probably to non-brittle underflow. However, both underflow and the gravity-glide emplacement of tectonic sheets within the upper plate are related to intumescence and distension of the area of the metamorphic-core complexes.

The possibility cannot be excluded that, for reasons not yet understood, many of the areas marked by mylonitic gneiss and distended upper plates were the locus of abnormal heating, mobilization and extention more than once in geologic time.

REFERENCES

Armstrong, R. L., and Dick, H. J. B., 1974, A model for the development of thin overthrust sheets of crystalline rock: Geology, v. 2, no. 1, p. 35-40.

Hamilton, W. B., 1964, Geologic map of the Big Maria Mountains NE quadrangle, Riverside County, California, and Yuma County, Arizona: U. S. Geological Survey Geologic Quadrangle Map GQ-350.

Lucchitta and Suneson, 1979, Origin of a northwest-trending lineament, west-central Arizona (abs.): Geological Society of America Abstracts with Programs, v. 11, no. 3, p. 89.

Shackleford, T. J., 1980, Tertiary tectonic denudation of Mesozoic-early Tertiary(?) gneiss complex, Rawhide Mountains, western Arizona: Geology, v. 8, no. 4, p. 190-194.

been of great help to us and was similarly helpful to Dr. Ransome. During 1936-37 the Eagle Picher Lead Company made an examination of the area under the direction of George M. Fowler and generously contributed to the data collected. Acknowledgment is made of the contribution of Dr. C. A. Rasor, who assisted in the work.

Bibliography

Blake, W. P., The Geology and Veins of Tombstone, Arizona, Am. Inst. Min. Eng., Trans., Vol. 10, pp. 334-45, 1882.

Church, J. A., The Tombstone, Arizona, Mining District, Am. Inst. Min. Eng., Trans., Vol. 33, pp. 3-37, 1903.

Ransome, F. L., Deposits of Manganese Ore in Arizona, U.S. Geol. Survey Bull. 710, pp. 96-103, 113-19, Pl. V, 1920.

Butler, B. S., Wilson, E. D., and Rasor, C. A., Geology and Ore Deposits of the Tombstone District, Arizona, Univ. of Ariz., Ariz. Bureau of Mines Bull. 143, 1938.

Cerbat Mountains[64]

By Robert M. Hernon[65]

Introduction

Geography.—The Cerbat Mountains, in Mohave County, Arizona, extend for about 30 miles northward from Kingman, a town about 70 miles southeast of Boulder Dam. It is a desert range that attains altitudes of 5,000 to 7,000 feet and rises sharply for 1,500 to 3,500 feet above detritus-filled desert valleys. The erosion forms in this range are typical of granite and gneiss masses, except where remnants of lava flows cap mesas of the familiar southwestern type.

Water supply.—Water is not abundant in either the mountains or valleys. Some springs and wells are in volcanic rocks as at Kingman. The crystalline complex of the mountains has little primary porosity, and the small amounts of water generally found in it occur in fault fractures and joints. According to reports, wells in the detrital valley fills have yielded little water.

Literature.—The most extensive publication that deals with the Cerbat Mountains is by Schrader.[66]

Bastin[67] studied some of the rich silver ores during the secondary

[64] Paper prepared for, and originally presented at, the regional meeting of the A.I.M.&M.E. held at Tucson, Arizona, November 1-5, 1938.

[65] Assistant Professor of Geology, University of Arizona.

[66] F. C. Schrader, *Mineral Deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona* (U.S. Geol. Surv. Bull. 397, 1909).

[67] E. S. Bastin, *Origin of Certain Rich Silver Ores Near Chloride and Kingman, Arizona* (U.S. Geol. Surv. Bull. 750, 1924), pp. 17-39.

sulphide-enrichment investigations. Brief summaries of the geology and ore deposits have been given by others.[68]

Production.—The production[69] of the Cerbat Range through 1930 is given as follows:

Copper (lbs.)	Zinc (lbs.)	Lead (lbs.)	Gold	Silver	Total
2,900,000	95,587,344	55,350,000	$2,339,000	$5,038,000	$20,270,000

To this should be added approximately $170,000 for 1931-36, inclusive, and an unknown amount for some early production which, because of marketing conditions, was not credited to the Cerbat Range. The value of the total production is estimated at $21,000,000 to $25,000,000. Nolan[70] records that the mines of the Wallapai district produced 548,035 tons of ore valued at $13,955,473 during 1902-32.

The largest past producers by far have been the Tennessee and Golconda mines. The important producers at present are the Tennessee-Schuylkill and the Arizona-Magma mines near Chloride, and Keystone, Inc., which operates in Mineral Park and in and near the "Top of Stockton Hill" area. Some custom milling ore was produced in 1937-38 by the Minnesota-Connor Mine. Numerous other mines are yielding shipping ore and custom mill ore to small operators and lessees.

The larger mills include those of the previously mentioned main active operations, besides the Oro Plata mill (now idle), and the General Ores Reduction custom mill.

History.—Most of the mines of the Cerbat Mountains were discovered between 1863 and 1900. The metals sought in the earlier days were gold, silver, and lead. Rich silver chloride, silver sulphide, and native gold ores were exploited first. With cheaper transportation, base-metal ores were mined for lead with low silver. Subsequent improvement in milling methods led to exploitation of complex lead-zinc ores. The later history of the area is essentially the history of the Golconda and Tennessee mines, as they were affected by metal prices and marketing conditions and by milling methods.

The area reached its peak production in the years 1915-17, when the annual yield averaged nearly $3,000,000. This peak coincided with high metal prices. After the World War, production was small until 1936 when the Tennessee-Schuylkill Corporation began operations.

[68] R. T. Mason, *Mining in Northwestern Arizona* (Min. and Sci. Press, 1917), pp. 627-28.
N. H. Darton, *A Résumé of Arizona Geology* (Univ. of Ariz., Ariz. Bur. of Mines Bull. 119, 1925), p. 180.
W. Lindgren, *Mineral Deposits* (4th ed., 1933), pp. 578-79.
E. T. McKnight, *Mesothermal Silver-Lead-Zinc Deposits* (Am. Inst. Min. Eng., Lindgren Volume, 1933).
T. B. Nolan and others, *Mineral Resources of the Region around Boulder Dam* (U.S. Geol. Surv. Bull. 871, 1936), pp. 18-19.

[69] Morris J. Elsing and Robert E. S. Heineman, *Arizona Metal Production* (Univ. of Ariz., Ariz. Bureau of Mines Bull. 140, 1936), pp. 73, 95.

[70] *Op. cit.*

The Tennessee Mine had a small production in the early nineties. Schrader[71] states that for some time during the period 1897-1903, it yielded thirty to fifty carloads of concentrates per month, besides high-grade ores. In 1910 a new shaft was sunk. The Needles Mining and Smelting Company operated the property until 1916 and produced a considerable tonnage of excellent grade ores. Restricted, intermittent operations characterize the years 1917-36.

The Golconda Mine, which was developed later than the Tennessee, made a small production early in this century. A good zinc ore shoot was reported developed about 1907. From 1908 to 1917 the Golconda was exploited to the 1,100-foot level and reached its maximum production in the years 1915-17, a period that coincided with the greatest production from the Tennessee Mine. Attempts have been made to reopen the Golconda since the World War, but it has produced only from shallow workings.

Geology and Ore Deposits

The facts concerning the geology were derived from published data, information supplied by geologists who have worked in the district, and the writer's observations made mainly in the east-central part of the mineralized area. No detailed geologic map of the range exists.

Rocks.—The rocks of the Cerbat Range consist of pre-Cambrian crystalline rocks, later crystalline rocks of unknown age, and volcanic rocks of probable Tertiary and Quaternary age. Some of the Paleozoic and Mesozoic sedimentary rocks of the Colorado Plateau probably extended over the Cerbat area but were removed by erosion before the Tertiary volcanic activity.

The crystalline rocks of the Cerbat Range form a complex predominantly of granite with diorite and gabbro, all generally somewhat gneissic and intruded by pegmatite, medium-grained granite, diabase, granite porphyry, and lamprophyric dikes. Small- to medium-sized blocks of very dark schist (amphibolite) are locally common. All these rocks show various degrees of schistosity and represent two or more eras.

The rocks as classified by Schrader[72] are here summarized.

Quaternary	olivine basalt flows and detritus
Tertiary	thick volcanics
(? Mineralization)	
Mesozoic (?)	granite porphyry, diabase, minette and vogesite dikes
Pre-Cambrian	coarse-grained, porphyritic, gneissoid granites, granite altered to schist, diorite, amphibolite, graphite schist, pegmatite

Granitic rocks greatly predominate in the range. The lamprophyric dike rocks are locally termed "diabase," and much of the granite porphyry of local usage is actually porphyritic granite.

[71] *Op. cit.*, p. 54.
[72] *Op. cit.*, pp. 27-42, 49-118.

The pre-Cambrian rocks are slightly to strongly schistose, and the schistosity generally strikes northeasterly but locally north or northwesterly. Pegmatite commonly occurs in tabular masses along the pre-existing schistosity. Large masses of pegmatite crop out north of Kingman; one such mass is being exploited for feldspar.

The Mesozoic (?) rocks are of undetermined age. According to Schrader[73] they cut pre-Cambrian rocks and are older than the Tertiary volcanic rocks. The ore deposits are associated with rocks of this group in space and time. The vein faults cut across the members of the pre-Cambrian group of rocks and probably across the diabase, but monzonitic dikes and highly altered dikes with quartz phenocrysts intrude along the faults and are cut by the mineralized fissures. The lamprophyric dikes also intrude the vein faults and are mineralized. The diabase has been seen to form one wall of veins and appeared to be older than the vein faults. It closely resembles the diabase sills in the Grand Canyon series and in the Apache group of southeastern Arizona. All the rocks grouped as pre-Cambrian and Mesozoic (?) may show north to northwest sheeting that appears to pass into true schistosity where most intense; this sheeting and schistosity appears to be related to the northwest system of faults.

The prominent felsitic Broncho dike of the Cerbat mining district is said to cut off and offset northwest-striking faults and their vein filling. This dike may be related to the Tertiary rhyolitic volcanic rocks. A small, similar dike crops out in lower Cerbat Wash.

The Tertiary volcanics are limited to remnants around the margins of the Cerbat Range and to the crest in the extreme north and south parts of the range. According to Darton[74] they are principally rhyolite flows, tuffs, and agglomerates. The absence of veins of the Cerbat type in the volcanics and the presence of felsitic dikes cutting across the veins are evidence that the mineralization is of pre-Tertiary age. The volcanics are absent over the main mineralized area, however, and the strike of the veins is the same as in Oatman district, where the veins are younger than volcanics probably contemporaneous with the rhyolitic series of the Cerbat Range.

A considerable thickness of detritus occupies the valleys. Some of the older detritus is covered by Quaternary olivine-basalt lava which laps over on older bedrock.

Structure.—Pre-Cambrian and later structures are not well known because of the small amount of detailed mapping in the range. The older rocks and structures are cut by faults of northwest strike. These faults are of two directions at any one place and appear to represent relief by shearing. Striations generally indicate that movement along steeply dipping faults had a larger horizontal than vertical component. Some minor faults of about

[73] *Op. cit.*, p. 30.
[74] *Op. cit.*

50 degrees dip are striated parallel with the dip. That the rocks now visible were faulted under deep-seated conditions is indicated by clay gouge and finely crushed rock along the tight fissures; no open breccia is present except postmineralization breccia in the quartz veins. Tear fractures in the wall of the faults, attitude of striations, tightness of the faults, and the development of two directions of breaks, indicate stresses were mostly compressive and that the yield was mainly by shearing.

At least four main periods of movement are discernible along the vein faults. The initial break and one period of reopening were premineral in age; one main reopening occurred during mineralization; and movement occurred after mineralization was complete.

The most prominent direction of jointing and sheeting is northwesterly. Postmineralization cross faults are known at several places in the range.

Veins.—The veins were formed by solutions rising along the system of northwest fault fissures. It is estimated that the mappable veins would aggregate a total length of 100 miles and perhaps twice that length within the main mineralized area. Much of the vein matter is barren or of very low grade but locally is ore; narrow, noncommercial stringers of the valuable minerals may persist for long distances along or in barren vein filling.

The veins consist mainly of fine-grained quartz with pyrite, galena, sphalerite, and other minerals. Lindgren[75] classes them as mesothermal, pyritic galena-quartz veins of the Freiberg type, although they contain some gold. The veins generally do not exceed 5 to 10 feet in width, although locally, some are as much as 25 or 30 feet wide. Their ore shoots as a rule are 0.5 to 4 feet in width, though lenses attain widths of 6 to 14 feet in the largest ore shoots. The veins locally show a rough banding.

Mineralogy.—The minerals ordinarily seen in hand specimens of sulphide ore are quartz of three ages, pyrite of two or more ages, galena, and sphalerite. Bastin[76] records the following minerals in the rich silver ores; those marked with an asterisk are rare under the conditions indicated.

Oxidation products: cerargyrite, native silver,* copper pitch ore,* malachite,* native copper.

Secondary sulphide enrichment products: argentite,* proustite (very rare),* covellite,* chalcocite.

Primary (hypogene) minerals: quartz (generally gray and finely crystalline), manganiferous siderite,* calcite (white), pyrite, arsenopyrite, sphalerite, galena, chalcopyrite, tennantite,* argentite, proustite, pearceite,* polybasite.

Bastin emphasizes the arsenical nature of the high-grade silver ores. He notes that proustite is abundant in such ores and tends to occur with tennantite.

[75] *Op. cit.*, p. 578.
[76] *Op. cit.*, p. 35.

Bastin[77] found native silver near fractures and vugs showing oxidation. He notes that native silver ores grade directly into rich sulphide ores below and appear to be somewhat below the silver chloride ores.

Character of ores.—The unoxidized ore shoots are generally complex assemblages of galena, sphalerite, and gangue minerals, which carry gold, silver, and a small amount of copper. Indium is reported in some ores of the range. A few unoxidized ores are essentially gold-silver ores with normally low percentages of base metal. The greatest production, however, has been of lead-zinc ores with some gold and silver. Production statistics seem to indicate that ores with high-grade zinc carry the most gold and ores with high-grade lead the most silver, but the association does not appear to be a close one. Gold occurs with a bronzy pyrite according to Garrett,[78] geologist at the Tennessee Mine. Some gold may be associated with arsenopyrite. Silver occurs as argentite and sulpho salts in unoxidized ores, as previously described.

Mineralization.—The sequence of mineralization has not been determined in detail. Main stages are as follows: Some vein faults or parts of vein faults were intruded by dikes before mineralization began. Reopening followed with introduction of quartz along most of the length of faults, whether or not intruded by dikes. This produced quartz veins or lodes in places as much as 30 feet wide. Some pyrite crystals appear to be associated with this early quartz. Mineralization had probably largely ceased when reopening of the fault fissures occurred. Solutions brought in the valuable constituents of the veins, and quartz was reworked with apparently little further addition of silica. A weak reopening followed, with introduction of a little quartz as veinlets that cut the sulphides. Later reopenings produced quartz breccias and more gouge, but mineralization seems to have completely ceased.

Vertical or concentric zoning does not appear to be striking. Zinc is said to increase with depth, but high-grade lead is found in considerable amount in depth. Copper is said to increase slightly with depth. A type of horizontal zoning is found in some ore shoots: more or less vertical or steeply raking sections of a single ore shoot are characterized by high gold, high lead, or high zinc. These horizontal variations appear to be due to changes in stability of minerals with time, as acted upon by successive intermineral reopenings. Either sphalerite or galena may occur without the other; sphalerite appears to be the earlier mineral.

Wall-rock alteration is not extensive except where strong silicification of sheeted zones occurred in the early quartz stage. The granitic rocks appear to have silicified more readily than basic dikes or schist masses. Microscopic study of the wall rocks might show more extensive alteration than is apparent to the eye.

Localization of ore shoots.—In the main mineralized sections of the Cerbat Range the 100 or more miles of vein outcrops are

[77] *Op. cit.*, p. 36.
[78] S. K. Garrett, personal communication, 1938.

composed mainly of barren or very low-grade material. According to available production records, only two mines, the Tennessee and the Golconda, exceeded a total production of $1,000,000. While a great many mines have made appreciable productions, the geological conditions favorable for ore bodies of the size of the Tennessee and Golconda are rare. These two ore shoots were explored for vertical distances of 1,600 and 1,400 feet, respectively.

Schrader[79] noted that some ore shoots coincide with intersections or forking of veins. Many vein intersections, however, do not show ore shoots.

Ore shoots appear to be localized where changes of strike or dip of the vein faults gave rise to open spaces due to the reopening movements that occurred just before and during mineralization. Open space filling seems to have been most important as far as valuable vein minerals are concerned. Areas of faults choked by either clay gouge or greatly crushed rock were too tight for big ore shoots. No striking control of ore shoots by wall rock is known. One small shoot was seen to pinch out where the vein passed from granitic rock to dense black schist.

Oxidation.—Weathering of the veins is incomplete where the filling is highly siliceous, except along open fractures or where the vein is brecciated. High-grade sphalerite ore shoots or heavy pyrite streaks were more or less completely oxidized and leached. Galena, however, is often seen on natural outcrops. Water level is ordinarily at depths of 25 to 250 feet, but oxidation does not tend to be prominent for more than 30 to 100 feet, except along open fissures. Ground water is rich in chlorine, according to Bastin,[80] who found 80 parts per million in a stream near the town of Chloride.

Secondary enrichment.—Bastin[81] does not believe that secondary sulphide enrichment of silver and copper is important in rich silver ores. His microscopic studies indicate argentite, occurring in funguslike patches, to be the main secondary silver mineral. He found pearceite and abundant proustite intimately associated with primary sulphides to be probably primary.

Several veins, however, may have undergone considerable secondary enrichment. An exploited vein in Mineral Park shows small base-metal shoots with good silver content that dropped out below the third level. The narrow Alpha vein in the Cerbat district has a strong gossan at the outcrop. Schrader[82] noted silver sulphide, pyrite, galena, zinc blende, and chalcopyrite in Alpha ore. Chalcocite can be seen in some specimens. Ores mined recently had high copper and silver content and appeared to be secondarily enriched.

Regardless of whether the veins have been enriched primarily or secondarily in silver, available evidence does not indicate that

[79] *Op. cit.*, p. 51.
[80] *Op. cit.*, p. 18.
[81] *Op. cit.*, pp. 36-37.
[82] *Op. cit.*, p. 103.

high-grade silver can be expected to extend downward more than a very few hundred feet.

Gold has been enriched residually by leaching of zinc and iron from heavy sulphide ore shoots carrying relatively low primary gold. A thin zone of very rich gold ore is reported near the bottom of the oxidized zone in several veins. This may be secondary gold. Nature of gangue, ground-water chloride ion, common presence of pyrite, and persistent though only locally abundant manganese oxides are all favorable for gold enrichment. Some gold enrichment has occurred, but how much residual and how much chemical is unknown. Such gold ore shoots have been small, but some were spectacular. Many sections of veins that are very low grade in the sulphide zone have yielded small bodies of gold ore of shipping grade from the oxidized zone.

Summary.—The Cerbat Range is an area of numerous veins with mostly small ore shoots. The excellent grade ores and fair-sized shoots of several mines indicate the area to be important and worthy of study. The great need of the present is for a good topographic map of adequate scale and for a sufficiently detailed geologic map to bring out essential features. Many problems of structure, petrology, ore occurrence, and mineralogy are unsolved. Microscopic study of ordinary sulphide ores is needed. The exact manner of occurrence of gold and silver in ores of ordinary grade should be determined.

Acknowledgments.—The writer is indebted to G. M. Fowler, of Joplin, Missouri, for direction and for the opportunity to study part of the Cerbat area. Many local people facilitated the field work and gave information.

Tennessee-Schuylkill Mine[83]

By S. K. Garrett[84]

Location

The Tennessee-Schuylkill Mine is at the western foot of the Cerbat Range, about 1 mile east of Chloride, in the Wallapai mining district, Mohave County, Arizona.

Rocks

The rocks of the Wallapai mining district can be grouped as diorite gneiss, granite, quartz monzonite porphyry, rhyolite, and diabase. The oldest rock, diorite gneiss, has been intruded by granite, and both the diorite gneiss and the granite have been intruded by quartz monzonite porphyry. The rhyolite and diabase

[83] Paper prepared for, and originally presented at, the regional meeting of the A.I.M.&M.E. held at Tucson, Arizona, November 1-5, 1938.
[84] Geologist, Tennessee-Schuylkill Mine.

Mohave Cty?

In Italy, Montana and Alberta, the Cretaceous-Tertiary boundary occurs in a zone of reversed polarity. Yet in the Raton and possibly the San Juan Basin, the boundary occurs in a zone of normal polarity. This suggest that K/T extinctions were diachronous on the continents and/or marine extinctions were diachronous with respect to continental extinctions which progressed latitudinally with respect to time.

Because of its occurrence at the base of a coal, strong doubt is cast on the validity of the iridium anomaly in the Raton Basin as representing an asteroid impact. Published data indicate the coal formation can concentrate platinum group metals and iridium concentrations as high as 15 ppm have been reported from coals of various ages and different localities.

CHARACTERISTIC MAGNETIZATION OF CRETACEOUS/TERTIARY BOUNDARY CLAYSTONE IN RATON BASIN IS REVERSED

Nº 13586

SHOEMAKER, E. M., U.S. Geological Survey, Flagstaff, AZ 86001; PILLMORE, C. L. and TSCHUDY, R. H., U.S. Geological Survey, Denver, CO 80225; and ORTH, C. J., Los Alamos National Laboratory, Los Alamos, NM 87545

The Cretaceous/Tertiary boundary, identified on the basis of the disappearance of four pollen taxa, has been located at nine sites in the Raton Basin of Colorado and New Mexico. A distinctive claystone layer with an anomalous abundance of iridium occurs at the boundary at each of these sites. Intensity of remanent magnetization of the boundary claystone is low (2×10^{-8} to 7×10^{-7} emu/cc). In all samples studied, the NRM directions are intermediate between mean normal and reversed directions for the Paleocene. The virtual north paleomagnetic pole for the majority of the samples, however, is in the southern hemisphere. Samples from two sites in New Mexico (Raton and Sugarite Canyon), where the NRM intensities are all above 10^{-7} emu/cc, were AF demagnetized in steps to 800 Oe peak alternating field. When demagnetized above 200 Oe peak field, directions of magnetization of the samples from the Raton site shifted progressively from normal to reversed. Directions of samples from the Sugarite Canyon site, which are reversed to start with, shifted closer to the mean Paleocene reversed direction when demagnetized above 400 Oe. The paleomagnetic observations clearly show that the characteristic magnetization of the iridium-bearing boundary claystone is reversed and that the boundary claystone probably was deposited during an epoch of reversed magnetic polarity, as has been deduced from paleomagnetic observations in Italy, Denmark, and Montana.

THE NEWPORT FAULT: EOCENE CRUSTAL STRETCHING, NECKING AND LISTRIC NORMAL FAULTING IN NE WASHINGTON AND NW IDAHO

Nº 19695

HARMS, Tekla A., Department of Geological Sciences, Queen's University, Kingston, Ontario K7L 3N6, Canada, and PRICE, Raymond A., Geological Survey of Canada, 601 Booth street, Ottawa, Ontario K1A OE8, Canada.

The Newport Fault, a low-angle, spoon-shaped, north-plunging, listric normal fault, juxtaposes a suprastructure of Middle Proterozoic (Belt) and Paleozoic miogeoclinal strata with unconformably overlapping Eocene rhyodacites and fluvial deposits over a mid-crustal level infrastructure ("metamorphic core [illegible]") comprising basement gneisses, granitic plutons and Belt metasediments that grade upward nearby into the Belt rocks of the suprastructure. Mylonite [illegible] the fault zone is gradational with footwall rocks, but is overlain and crosscut by chloritized microbreccia that forms a layer 1.5 -5.0 m thick, the [illegible] of which is a sharp contact with hanging wall rocks showing "reverse drag" [illegible]ing. Slickensided shears in the microbreccia and the fabric of the mylonite [illegible] that the metamorphic infrastructure moved upward and outward to the east and west as the hanging wall mass subsided into the depression above a zone of ductile necking in the infrastructure. Mylonite, which formed by [illegible]ic flow in the fault zone at depth, was juxtaposed below, and partly overprinted by microbreccia, which formed by brittle fracture near the surface in the same fault zone, during one episode of normal-slip displacement [illegible] a crustal scale. The 48 Ma-old Silver Point pluton, emplaced in the zone of the necking, became lineated during stretching and was cut by the fault. It [illegible]s movement on the fault, as do the widespread 45-50 Ma K-Ar quenching [illegible] in the tectonically denuded metamorphic infrastructure, and the Early [illegible] Middle Eocene volcanic and clastic "growth-fault-basin" deposits which [illegible] cut by the fault. The crustal stretching recorded by the Newport Fault [illegible] related to right-hand slip on the Lewis and Clark-Hope fault system, [illegible]wise rotation of rocks of the Washington Coast Ranges, and right-hand [illegible] on the en echelon Fraser River-Straight Creek and Tintina-Northern [illegible]y Mountain Trench transform fault systems.

[illegible]ARY DENUDATION, ARCHING, AND FOLDING OF [illegible]NENTAL CRUST, WESTERN ARIZONA

Nº 19584

[illegible]ON, J.K., U.S. Geological Survey, P.O.Box 25046, Denver,CO 80225

[illegible]ary extension in western Arizona produced a regional low-angle [illegible]ment fault that extends over a broad northwest-trending area [illegible] the Harcuvar metamorphic core complex. The complex is characterized by northeast-trending structural arches and sags. Exposed in [illegible] arches are lower plate crystalline rocks of Precambrian to [illegible]ary age. Preserved in the sags are fault slices consisting largely of lower plate Paleozoic and Mesozoic metamorphic rocks and folded rocks of early Miocene age. The Miocene rocks rest with fault or depositional contact on and contain clasts of the lower plate metamorphic rocks. The folds are open, upright, and trend northwest across the trend of the arches and sags. In contrast, the complex is flanked to the north, east and southeast by an upper plate of homoclinally tilted fault blocks that consist of Precambrian crystalline rock and overlying Tertiary units. The Precambrian crystalline blocks are remnants of an inferred, once continuous, upper plate, 1.5 to 3 km thick. Dating of units in tilted fault blocks suggests that deformation began before 28 m.y.B.P., ceased on the northeast edge of the complex about 21 m.y. B.P., but continued to the west until 14 to 16 m.y. B.P. Clast compositions in dated upper plate Tertiary rocks indicate that lower plate Paleozoic and Mesozoic metamorphic rocks were exposed to erosion as early as 26 m.y.B.P. Denudation sufficient to expose Mesozoic and Paleozoic metamorphic rocks in late Oligocene time is inferred to have utilized an early-formed version of the presently exposed northeast-dipping detachment surface. Continued movement on the detachment surface caused minor deformation of basin beds deposited on the exposed detachment. Regional northwest-trending arching of the denuded complex and development of northeast-trending arches and sags followed in mid-Miocene time.

EXTENSIONAL FAULTING THROUGH THE UPPER CRUST, CALIFORNIA-ARIZONA BORDER

Nº 19592

HOWARD, Keith A. and JOHN, Barbara E., U. S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025

Large Miocene extension in a NW-trending belt occurred along NE-dipping faults that traversed the upper crust and flattened at middle crustal depths. Allochthonous NW-trending fault blocks tilted SW define a 100-km width for the belt, measured from near the Old Woman Mountains, Calif. to near the Hualapai Mountains, Ariz. Low-angle normal (detachment) faults below the shingled fault blocks originally dipped NE into the middle crust from a headwall of steep normal faults in the west. Detachment faults at several levels each displace their footwalls SW relative to higher plates, the same sense as between higher rotating blocks. An initial depth greater than 12 km for parts of the Whipple Mountains-Chemehuevi detachment fault is suggested by structural reconstruction of overlying allochthonous slabs of basement rock once this thick and now upended in the Mohave Mountains. Brittle thinning above this fault thus affected the entire upper crust, and in places wholly removed it to expose middle crustal rocks below the fault as "core complexes". Cooling by rapid removal of more than 10 km of cover can account for Tertiary K-Ar ages common in pre-Tertiary rocks in the core complexes. Older K-Ar ages reflect rocks that lay at shallower crustal levels before extension, and are now mostly in upper plates. Increased development to the NE of chlorite breccia below detachment faults accords with inferred initial dip and greater depth of greenschist metamorphism of breccia to the NE. Upwarping and rotation by rebound of the denuding core complexes brought dipping detachment faults to subhorizontal positions. The detachment faults appear to root NE below the Hualapai Mountains and the Colorado Plateau. Unidirectional slip on faults at levels throughout the upper crust and into the middle crust supports a model of rooted normal faults, below which California pulled relatively SW away from Arizona.

A CONTINUUM OF DUCTILE TO BRITTLE EXTENSION IN THE SOUTH MOUNTAINS, CENTRAL ARIZONA

Nº 19578

REYNOLDS, Stephen J., Arizona Bureau of Geology and Mineral Technology, 845 N. Park Ave., Tucson, AZ 85719

Rocks within the South Mountains of central Arizona have undergone an episode of middle Tertiary extension that spans the ductile-brittle transition. This deformation has overprinted Proterozoic amphibolites and several middle Tertiary plutons, with discrete phases of mylonitization being associated with each middle Tertiary intrusive pulse. Mylonitic fabrics reflect extension parallel to east-northeast-trending lineation, flattening perpendicular to subhorizontal foliation, and a strong component of east-northeast-directed shear. A decrease in ambient temperature and pressure during successive stages of mylonitization is indicated by 1) progressive decrease in grain size of synkinematic intrusions; 2) increased localization of mylonitic fabrics; 3) increased importance of brittle processes; and 4) Rb-Sr and K-Ar geochronology. Mylonitization was succeeded by more brittle deformation that produced chloritic breccia and microbreccia in the footwall of a major, east-dipping detachment fault. The detachment fault and underlying breccia were formed by normal faulting and brittle extension in an east-northeast direction. A complete continuum between mylonitization and brecciation-detachment faulting is indicated by 1) precise kinematic coordination between mylonitic and brittle fabrics; 2) close spatial and temporal association between mylonitization and brecciation; and 3) the presence of fabrics that are transitional in character between mylonitic rocks and nonfoliated breccia. The transition from ductile to brittle extensional deformation is consistent with progressive unroofing of a normal-slip shear zone of crustal proportions.

GSA 1983

Min. & Sci. Press v113 no. 21, p. 733, 1916

...e Ore Deposits of Mohave County, Arizona

By Frank C. Schrader

...UCTION. *This region, commonly known as the ... district and Kingman district, lies in western ... in the southern part of Mohave county, and ... California and Nevada on the west. Kingman, ...ipal town, is situated near the centre of the area ... Atchison, Topeka & Santa Fe railway.

...region is composed of naked mountains and broad ...-filled valleys, the southern extension of ...aracteristic topography of the Great Basin. ...itude it varies from 500 ft. in the south-west ... ft. on Hualapai Peak south-east of King-...

... mountains trend north-northwest. They ...out 3000 ft. above the valleys, are generally ...i. and were formed mainly by erosion. ... are composed in the main of a complex of ...Cambrian granitoid rocks that underlies the ... as a whole. Like the valleys, they average ... 10 miles in width.

...LOGY. [1]The rock groups beginning with ...ldest are the pre-Cambrian complex, Paleo-... sediments, pre-Tertiary intrusives, Tertiary ...anics, and Tertiary (?) and Quaternary sedi-.... The first and third of the divisions named ... the most important.

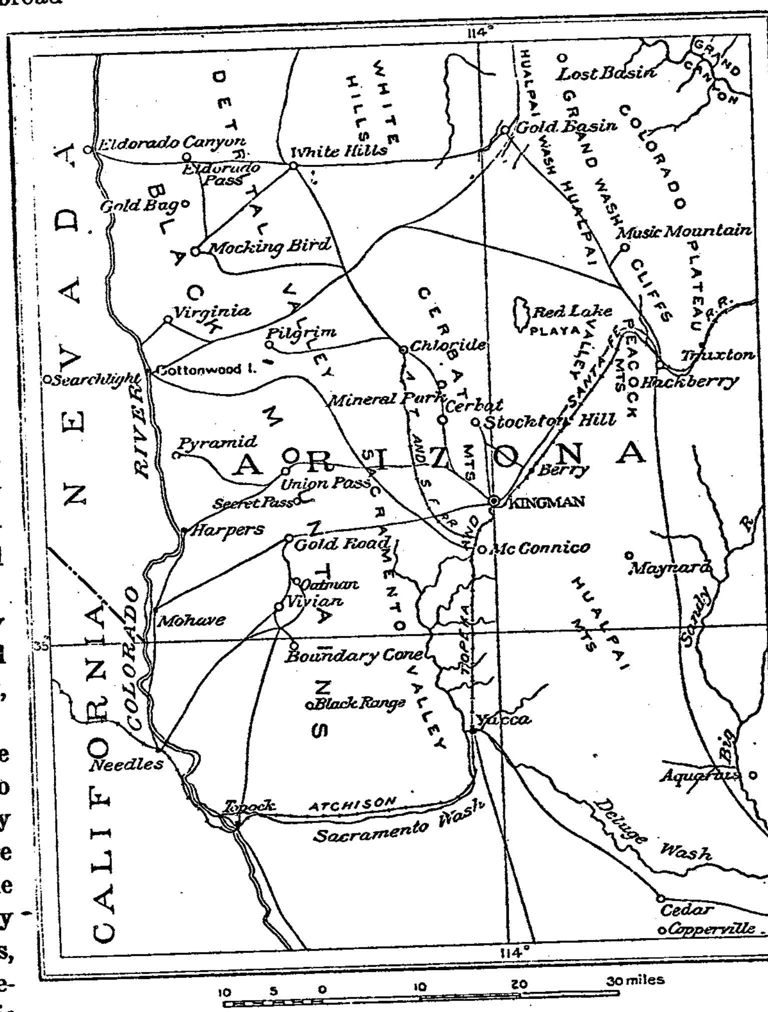
The pre-Cambrian complex consists of gray ...oid granites. Coarse gold-bearing detrital ...ations, or 'wash,' locally 2000 ft. thick, ...ly fill the inter-montane valleys.

...ally intruding the pre-Cambrian rocks are ...-Tertiary igneous masses and dikes thought to ... late Jurassic or early Cretaceous age. They ... chiefly in the Cerbat mountains and are ...ected with the genesis of the deposits. The ... important are granite-porphyry, a light gray ...ium-grained rock, and lamprophyric rocks, ... latter occurring mainly as dark, comple-...ary narrow dikes accompanying the acidic ...rusives.

The Tertiary volcanics consist mainly of an-...ites, trachytes, rhyolites, and latites, lying in ...ad superimposed sheets, flows and beds locally aggre-...ing 3000 ft. thick. They are best developed in the ...ack mountains, particularly in the southern part. ...y contain most of the mineral deposits of the range ... played an important part in their genesis.

The beginning of mining in the Mohave area dates ...om the finding of ore at the Moss mine, four miles north-west of Gold Road in the early 'sixties. From 1904 to 1914 the production was nearly $16,000,000, of which $11,500,000 was gold, nearly all derived from the Tom Reed and Gold Road mines. Besides gold and silver, zinc, lead, copper, tungsten, molybdenum, and bismuth are produced.

THE TOM REED-GOLD ROAD district lies about 25 miles south-west of Kingman, mainly on the west slope of the range; it comprises what was formerly known as the Gold Road and Vivian districts, the area being approximately co-extensive with the southern part of the San Francisco district of early days. The principal centres of activity are Oatman, the settlement of the Tom Reed and neighboring mines, and Gold Road, two miles north of Oatman.



Bulletin 397, U. S. Geological Survey.

MAP OF ARIZONA MINING DISTRICTS.

Mineral was first discovered in the early 'sixties at the Moss mine, four miles north-west of Gold Road. This mine soon produced $240,000 in gold from rich surface ore. Production has continued since the discovery of

*Abstract from paper to be presented at the New York meet-...g (February 1917) of the American Institute of Mining Engineers.

[1]A fuller description of the rocks appears in Bulletin No. ..., U. S. Geological Survey (1909).

the Gold Road mine in 1902. Recently discoveries in the Tom Reed mine and vicinity have been attracting attention, with the result that the value of the plants and machinery at the various mines is said to aggregate nearly $2,000,000. Some 50 odd plants are in operation. Most of them have been installed since the first of the year 1915, during which time nearly 200 companies have been organized to operate in the district, of which 150 are fully equipped and most of the others are receiving machinery. Thirty or more properties hitherto dormant have become active, and the population, which is gathered from all the mining camps in the West, has increased from 600 to more than 7000, and is increasing.

The approved method of prospecting is to sink to depths of 300 to 500 ft. and then cross-cut and drift. Practically no surface work is done. Usually also much lateral development must be done before pay-ore in large quantity is found and the mine proved. The automobile, a prominent feature in the present activity, has taken the place of the burro in prospecting.

The cost of mining and milling is about $6 per ton, of which $1.25 is for power. The larger mines use electric power supplied by the oil-burning plant at Kingman. At the Gold Road mine, treating 200 tons of ore daily, the best record obtained for mining and milling is slightly less than $3 per ton. At the Tom Reed mine, however, where 20 stamps are used, the cost is about $6. There is said to be no profit in treating $5 ore on a small scale. Both the Gold Road and Tom Reed mines treat their ore by the cyanide process, and have installed the counter-current decantation system.

From what has been said of the Tyro and Gold Road veins, and from the large number of other widely distributed profitable orebodies being found at depth, and the cost of mining and milling, this is not a locality for the small operator but seems rather to offer encouraging possibilities for capital to engage in deep mining.

GEOLOGY. Tertiary volcanic rocks prevail, particularly in the eastern portion of the district. They practically constitute the range, dip gently eastward toward its axis, and are in places covered by younger rhyolite, andesite, and basalt. In the southern part the green chloritic andesite is dominant, while on the west occur local areas of the pre-Cambrian gneiss, younger granite-porphyry and micro-pegmatite, greenstone agglomerate, and overlying sheets of supposed Tertiary conglomerate, younger gravel and lava flows. Locally intervening between the pre-Cambrian and the overlying volcanics are occasional patches of tilted and metamorphosed Paleozoic limestone and shale belonging to the Grand Canyon section. These sedimentary rocks are not as yet known to have any bearing on the deposits or on mining other than to indicate to the miner the lower limit of the volcanics.

Recent mine developments show that the geology of the ore-bearing volcanics is more complicated and seemingly of more importance than was at first supposed.

In the vicinity of Vivian, and from there toward Oatman, occurs the older or basal andesite, which is light-gray, calcitic, 300 ft. thick, and rests mainly on the pre-Cambrian complex and Paleozoic sediments. The older andesite, however, is not known to be of wide extent in the district, a fact overlooked by Bancroft and others. It is absent from Secret Pass where the next higher rock, the green chloritic andesite, rests directly upon the pre-Cambrian granite, and from the Hardy mountains, where the green chloritic andesite similarly rests upon the Mesozoic granite-porphyry or micro-pegmatite.[2] It is not known to be present at the Gold Road mine, and according to Sperr[3] the rock underlying the green chloritic andesite in the deep workings of the Tom Reed mine does not correspond with the older andesite described at Vivian. The older andesite is succeeded uncomformably by another series of flows, the green chloritic andesite, which contains an important part of the mineral deposits in the Tom Reed-Gold Road district. The flows aggregate a known thickness of 800 ft. The rock consists mainly of a greenish fine-grained groundmass containing abundant whitish feldspar phenocrysts. It is chloritic and calcitic. It is intruded by black latite and younger lavas.

The intrusive nature of the green chloritic andesite and association of ore deposits with its intrusive phases in various parts of the district are also abundantly corro-given off from the main mass, extend ⅛ mile or more westward into the older andesite. A black fresh-looking specimen of it from the Leland mine proved to be latite; it contains chlorite in abundance throughout.[4]

The intrusive nature of the green chloritic andesite and association of ore deposits with its intrusive phases in various parts of the district are also abundantly corroborated by the later work of Sperr, Probert, Bancroft, and other engineers. Probert[5] believes it to be both intrusive and extrusive, that dikes and sills of it occur in the older andesite, and that mineralization is dependent upon this association.

Bancroft[6] writes that in the vicinity of the various mines which he examined he found evidence of the intrusive nature of this formation, and that the orebodies are largely formed within the intrusive.

More recently, according to Smith,[7] the bottom as well as the collar of the Tom Reed shaft at 1075 ft. in depth was in the green chloritic andesite, which in the bottom of the shaft was ore-bearing, and he suggests that the rock may here be intrusive. The supposition of the rock being here intrusive, probably as a neck, would help to account for the unusual thickness of the formation at this point, which seems to be local, since elsewhere in the

[2]Bulletin No. 397, U. S. Geol. Sur., p. 35, and Fig. 2 (1909).

[3]J. D. Sperr: 'The Tom Reed-Gold Road Mining District, Arizona,' *Eng. and Min. Jour.*, vol. 101, No. 1, pp. 1-5 (Jan. 1, 1916).

[4]Bulletin No. 397, U. S. Geol. Sur., pp. 36-37 (1909).

[5]Frank H. Probert: 'Oatman, Arizona—A Prohibition Camp,' M. & S. P., vol. 112, No. 1, pp. 17-20 (Jan. 1, 1916).

[6]Howland Bancroft: 'Geology of Gold Road District,' M. & S. P., vol. 3, No. 1, p. 21 (July 3, 1915).

[7]Howard D. Smith: 'The Oatman District, Arizona,' M. & S. P., vol. 3, No. 5, pp. 172-175 (July 31, 1915).

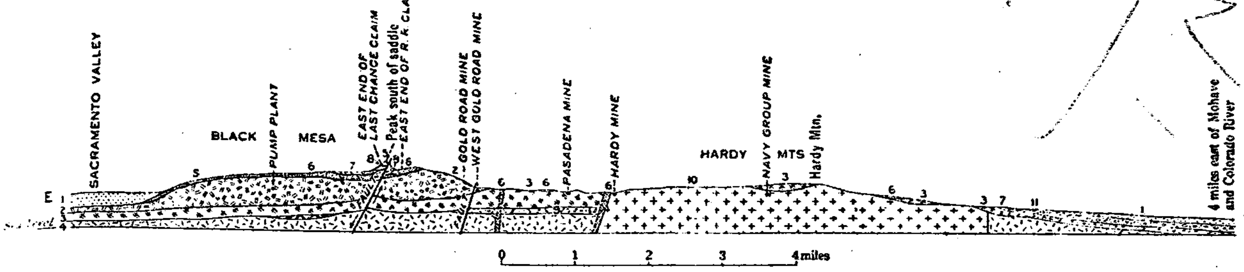
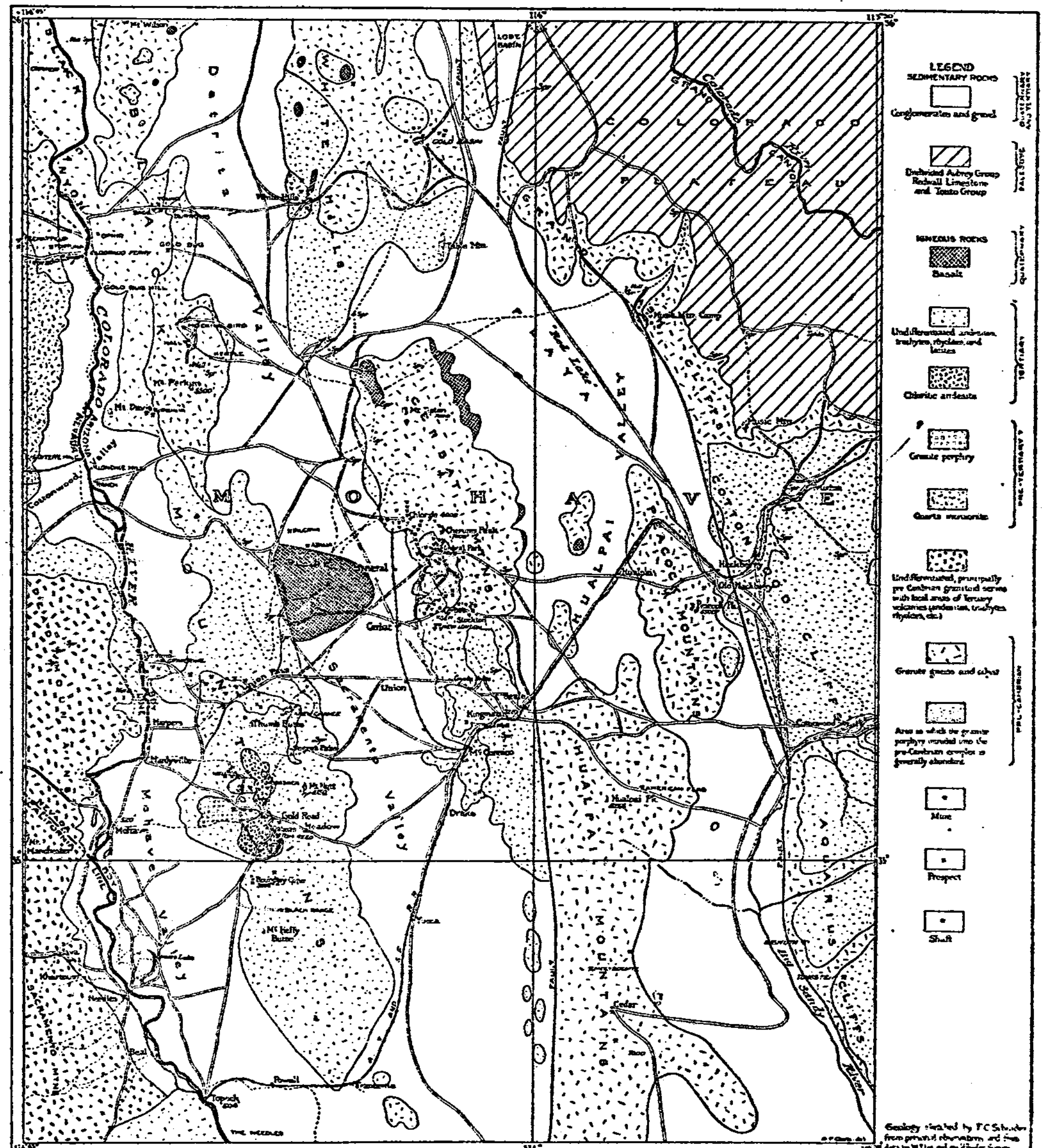


FIG. 2. GENERALIZED SECTION ACROSS BLACK MOUNTAINS. U. S. GEOLOGICAL SURVEY.

1, Sands and gravels; 2, undifferentiated volcanic rocks; 3, green chloritic andesite; 4, gneissoid granite; 5, basalt; 6, rhyolite; 7, young andesite; 8, rhyolite tuffs; 9, andesite and andesite tuffs; 10, granite porphyry and micro-pegmatite; 11, conglomerate.



GEOLOGIC RECONNAISSANCE MAP OF THE MOHAVE COUNTY MINING REGION, ARIZONA

Tom Reed mine and in the neighboring United Eastern, Pioneer, and other properties the workings, according to Schader,[8] passed through the green chloritic andesite and into the older underlying andesite at shallower depths and have workable ore in the lower rock.

Therefore, according to the observations of six or more investigators, the green chloritic andesite includes rocks that vary considerably from the normal andesite, rocks with which the ore deposits in general seems to be associated and which are known to be intrusive into the older andesite. The most important of these rocks seems to be the dark latite at the Leland mine and elsewhere. It seems to intrude not only the older andesite but also the green chloritic andesite as sheets, necks, and dikes, and to be intimately connected genetically with the ore de-

[8]Carl F. Schader: Personal letter, Feb. 6, 1915.

[9]J. D. Sperr: 'Conversational Geology at Oatman,' *Eng. & Min. Jour.*, vol. 101, No. 26, p. 1119 (June 24, 1916).

posits. More recently, Sperr[9] regards all the commercial ore as occurring in the andesites intimately associated with latites. The intrusive nature of the rocks associated with the ore deposits obviously favors continuity of the deposits in depth.

The deposition of the green chloritic andesite was followed by a period of great fissuring and faulting accompanied and followed by eruption of the next higher group, the undifferentiated volcanic rocks 2000 ft. thick, containing the Gold Road and other important veins, and by intrusions of younger rocks, especially latite and rhyolite in the form of dikes, necks, and rounded plug or stocklike masses, and the making of many of the larger fissure veins. The undifferentiated volcanics are succeeded by a series of younger light-colored tuffaceous rhyolites locally 1000 ft. thick, known as the 'water rock,' succeeded by dark reddish andesite, which in turn is followed by black olivine-basalt, the youngest of the effusive rocks, which remains as a cap over a large part of the Black Mesa mountains.

THE ORE DEPOSITS, which are numerous, are chiefly gold-bearing fissure-veins. They vary from 5 to 70 ft. in width and from a few hundred feet to several miles in length. In general they are strong and persistent. They strike north-west with steep dip north-east. They are almost devoid of metallic sulphides, the gold being free. They occur chiefly in the lower part of the undifferentiated volcanic series, the green chloritic andesite, the granite-porphyry, and micro-pegmatite, other underlying rocks, and also along contacts where latite and rhyolite are the intrusives. Some of the deposits are rich, but the large bodies of low-grade ore constitute the main resource. Ore having a metallic content of $10 or less is considered low-grade.

The older andesite, from the ill behavior and feathering out of certain vein deposits on entering it from the green chloritic andesite, was originally regarded by me as unfavorable for mineral or essentially barren, particularly in the Vivian district. Owing to its tufaceous brecciated and fragmental nature it is almost devoid of lava-cooling shrinkage-cracks and fissures, which elsewhere form favorable repositories for ore. According to Palmer[10] "the occurrence of any ore-shoots in the earlier (older) andesite is yet to be demonstrated." E. W. Brooks also limits the area of commercial mineralization in this part of the district to the green chloritic or 'younger andesite.' Later developments, however, in the Oatman and Vivian camps, disclose workable ore deposits in the older andesite also. My belief that major veins probably occur in and below this formation is shown by the following statement: "The veins cut through the great mass of Tertiary volcanic rocks which characterize the range and undoubtedly continue in depth into the underlying pre-Cambrian granitic rocks."[11]

According to Palmer,[12] "there is no doubt that the veins extend into the pre-Cambrian and some ore of value has been found therein."

Since the deposits are confined to the vein-filling and do not as a rule form metasomatic replacements in the wall-rock, as at Cripple Creek, the selective preference which any bounding wall-rock, by reason of its more favorable physical or chemical properties for replacement, may exert in favor of ore deposition seems to be practically nil. Accordingly, there is no apparent reason, other conditions being equal, why the deposits should not be equally developed in any one of several formations through which the fissure-vein with like strength may extend.

The deposits consist of two types: those in which the gangue is chiefly quartz and adularia, and those in which it is chiefly calcite. The source of the quartz and adularia is referred to the silicious magmas and that of the calcite to basic or andesitic magmas with possible contributions derived from underlying limestones. The former carry the best ore, occur mostly in the undifferentiated volcanic rocks and in granite-porphyry and have a general north-west south-east trend. The latter seem to occur mainly in the green chloritic andesite and trend more nearly north-south. Among the most important of the former type are the Gold Road and Tom Reed veins; among the latter, the Pasadena, Mossback, and Meals. In some cases the veins are associated with boldly cropping silicified dikes of which the deposits in certain instances may be a part replacement.

According to Platts,[13] the most productive veins, such as those in the Tom Reed, United Eastern, and Big Jim mines, are in a complicated series of fissures, part of which strike about N 45° W, and others N 60° W, producing with each other a conjugated system with numerous intersections near which many large orebodies are found.

Surficially, the veins seem to fall mostly into four main belts,[14] which, named in order from north to south, are the Gold Road, Tom Reed, Vivian, and Black Range. The Tom Reed belt is the best developed and contains the most interesting discoveries.

There seem also to be two or more horizons or vertical 'ore-zones.' The largest and richest orebodies seem in general to lie in a zone of enriched oxides between the 300-ft. and 500-ft. levels. Below this zone the ore decreases in value, but continues to be of workable grade beyond the deepest point yet penetrated. The richness of this zone as suggested by Smith[15] is probably due to secondary enrichment, by contributions leached from shallower depths, in support of which the presence of vugs and manganese oxide in the upper part of the veins is cited. This view is also corroborated by the tendency of the zone to parallel the contour of the surface. For instance, its occurrence at about the same distance from the surface in the Gold Road mine as at Oatman, though

[10]Leroy A. Palmer: 'The Oatman District, Arizona,' M. & S. P., vol. 113, No. 6, p. 195 (Aug. 5, 1916).

[11]Bulletin No. 397, U. S. Geol. Sur., p. 48 (1909).

[12]Leroy A. Palmer: *Op. cit.*, M. & S. P., vol. 113, No. 6, p. 195 (Aug. 5, 1916).

[13]J. B. Platts: 'Geology of Oatman,' M. & S. P., vol. 112, No. 23, p. 814 (June 3, 1916).

[14]Leroy A. Palmer: 'The Oatman District, Arizona,' *Eng. & Min. Jour.*, vol. 101, No. 21, p. 895 (May 20, 1916).

[15]*Op. cit.*, p. 173.

...rrespondingly greater elevations and higher geologic ...zons. The gold was probably precipitated in large ... along with the manganese oxide.

... the thickness of 600 or 800 ft. assigned to the green ...itic andesite be correct, this Oatman ore-zone, or, ... generally speaking, the triangular area of sev... square miles comprised between the Tom Reed, ...eer, and Pasadena mines, should lie mainly in this ...ation. There seems to be also present, notably at ...man and vicinity, a shallow or surface zone of leached ...es to which pay-ore found at or near the surface is ...rally confined. It extends to depths of about 150 ft., ...ween which and the zone of enriched oxides, or 300-ft. ...l. lies a 150-ft. intermediate zone of leached or rela...ely barren ground, although the valuable ore-shoots, ...ording to Sperr,[16] almost without exception come at ...st within 100 ft. of the surface.

These two zones have probably suffered about the ...me amount of leaching, the upper zone certainly not ...ss than the intermediate or barren zone. The upper ...one appears to owe its greater ore-content to the more ...licious, and consequently resistant, character of the ...re, which accordingly better withstands the process of ...aching.

As against the view of enrichment by leaching and re...position in the main zone of Platts[17] who holds that ...he ore is essentially a primary deposit formed by hot ...scending solutions, that from the nature of the gangue ...t is evident that acid solutions could not exist, and that, ...xcept for the oxidation of the pyrite, there is no evi...dence of the action of surface-water on the ore.

It seems quite possible, as suggested by one writer, that the ground-water table in the district may be in part dependent upon the neighboring Colorado river. If this view be correct, physiographic study will probably be able to correlate certain horizon features of the vertical section such as leaching, with relatively prolonged pauses in the historical down-cutting of the river. It does not, however, seem safe to assume that the water-table at Oatman coincides with the level of the Colorado river, which is 2000 ft. lower than Oatman, and that therefore the ores, if they persist downward, will continue to be oxidized and of the same milling character to that depth as advocated by Palmer.[18] Owing to the greater elevation of the gathering zone on the east, which probably extends to the Hualapai mountains, or longitude of Kingman, the ground-water table is not a level surface, but gradually rises from the Colorado river, eastward, and at Oatman it probably stands several hundred feet above the level of the river.

The ore occurs chiefly as a series of tabular or lenticular ore-shoots pitching variously within the vein, with which they exhibit some degree of parallelism. The shoots vary from 1 ft. wide to the width of the vein. They usually carry gold for their full width. They range up to nearly 1000 ft. in length and depth, and there is a general similarity or repetition of the shoots in the same vein. They seem to have been formed by thermo-aqueous processes that followed igneous activity. In general, the quartz and values favor the hanging wall, which is generally the better defined, and contains stringers branching off obliquely from the vein, while the spar or calcite favors the foot-wall. The gold is mostly associated with the quartz-adularia gangue and not rarely where sulphides have existed, it, according to Platts,[19] occurs in hematite (which is pseudomorphic after pyrite) in the quartz.

According to Palmer,[20] the first indications of the vein encountered in sinking are small stringers of quartz and calcite scattered through the andesite, usually accompanied by slight pyritization in the vein-wall andesite which yields a little free gold in the pan, while in the ore-shoots the vein matter shows pronounced hematite and manganese stains. It is said that the problem in development is not so much the finding of veins as the discovery of ore-shoots in the veins, that nothing sufficiently tangible has yet been found to use as the basis for a theory to guide the operator in the search for ore.

Though no rigid rule can be laid down to guide the operator in search for ore, nevertheless, from the apparently well-established facts that the metallic values have been largely imported by the replacement quartz-adularia solutions and that more gold is found where the replacement of calcite is most nearly complete, in formulating plans of exploration much benefit in most cases should be derived from a correlative study of the criteria indicating the probable courses followed by these solutions, namely, quartzose vein croppings, silicified wall-rock, the quartz pseudomorphic structures, etc., which have been described. It was the quartz adularia or silicious waxy-appearing character of the deposits seen in the Tom Reed mine and the recognition of their marked similarity to the then-producing deposits of the Gold Road mine that apparently led to the resumption of operations in the Tom Reed mine.

THE mine of the Vermont Copper Company at South Strafford, Vermont, is one of the oldest mines in the United States, having been first opened in 1793. The ore was mined to make copper sulphate and over 1300 men were employed at one time. More recently it has been operated intermittently as a copper mine, but owing to difficulties in smelting at each attempt, the mine was shut-down. The ore is pyrrhotite, carrying 2 to 2.75% copper as chalcopyrite. Some experiments were made last spring in treating this ore by pyrite smelting, and these experiments were successful. The mine is now under development to increase the tonnage available before further improvements are made.

TAILING is treated in Cornwall for its tin-content, and during August, 10,876 tons yielded 37.3 tons of black tin, containing 70% metal.

---

16 J. D. Sperr: 'Conversational Geology at Oatman, Ariz.,' *Eng. & Min. Jour.*, vol. 101, No. 26, p. 1119 (June 24, 1916).

17 J. B. Platts: *Op. cit.*

18 L. A. Palmer: *Op. cit.*, M. & S. P., vol. 113, No. 6, p. 196 (Aug. 5, 1916).

19 J. B. Platts: *Op. cit.*

20 L. A. Palmer: *Op. cit.*, p. 896.

R. ERNEST ANDERSON *U. S. Geological Survey, Federal Center, Denver, Colorado 80225*
CHESTER R. LONGWELL *Department of Geology, Stanford University, Stanford, California 94305*
RICHARD LEE ARMSTRONG *Department of Geology and Geophysics, Yale University, New Haven, Connecticut 06520*
RICHARD F. MARVIN *U. S. Geological Survey, Federal Center, Denver, Colorado 80225*

Significance of K-Ar Ages of Tertiary Rocks from the Lake Mead Region, Nevada-Arizona

ARIZONA SILVER CORP. CONTINENTAL SILVER CORP.

[redacted]

ARIZONA SILVER CORPORATION (ARZ-V, ARZ NF-Nasdag) CONTINENTAL SILVER CORP. (CVR-V, CTL SF-Nasdag)

[redacted]

MOHAVE COUNTY

~~NICOR MINERAL VENTURES~~

~~ANNUAL EXPLORATION REVIEW MEETING~~

~~January 20- 21, 1983~~

MINING PROJECT, 1977

CUSTOM MILL PROJECT

AND

MOHAVE COUNTY MINING PROJECT REPORT

MOHAVE COUNTY, ARIZONA

BY

VERNON DALE
SAM RUDY

MARCH, 1977

TABLE OF CONTENTS

ILLUSTRATIONS

TABLES

APPENDIX

INTRODUCTION AND ACKNOWLEDGMENTS

The purpose of this project was to attempt to find sufficient ore reserves in an area of Mohave County, Arizona on which to amortize a small custom or toll mill.

Mohave County has a significant and colorful history of small mine operations, which at the present time, are essentially non-existent. We believe one of the primary reasons is a lack of market.

The fact that every prospect is a potential mine until proved otherwise should not be overlooked. Deposits that show a reasonably large quantity of mineral but values too low to realize a profit under the existing conditions, or for which a market is absent, or where railroad rates to the nearest market are prohibitively high, cannot be termed valueless. Time, new developments in ore treatment, expansion of markets, new markets due to increased transportation facilities, etc., are the factors that change speculative value of a deposit into real value. There are no fixed rules for determining speculative value.

We believe that this mining-oriented project is the first of its kind where Federal, State and County governments and private individuals, have cooperated in an effort to stimulate mining activity. The Arizona Bureau of Mines, the U. S. Bureau of Mines, the Arizona Department of Mineral Resources and a number of individuals contributed published bulletins, professional papers, reports of investigations, information circulars, and private and other governmental reports on mining properties and areas in Mohave County. These contributions are gratefully acknowledged.

The following individuals loaned equipment to the project free of charge: C. G. (Pat) Patterson of Chloride, Arizona loaned a crusher; Mason Coggin, a mining engineer with Coe and Van Loo engineering consulting firm in Phoenix loaned a transit; Joe Hood of the County Highway Department, loaned a level rod and picks; the Project Engineer from the Department of Mineral Resources loaned miscellaneous equipment and tools. Both Mohave County and the Department of Mineral Resources supplied equipment and materials, and the County furnished office and storage space. All who participated in the project gratefully acknowledge the above assistance. In addition, acknowledgment is made of all those people who contributed personal, first-hand knowledge of many of the mines and workings for which we had no reports or the reports in files were inadequate.

SUMMARY

Although a considerable tonnage of ore reserves in dumps and tailing ponds was sampled during this project, much metallurgical testing remains to be done to find a metallurgical process or combination of processes that will efficiently and economically recover the gold, silver, lead, zinc and copper values from 100 to 300 tons of feed per day. The Tennessee-Schuylkill mill was a selective flotation plant which made a very good recovery, even though the tailing carries significant amounts today of residual silver and zinc. The U. S. Bureau of Mines made a rather detailed study of this milling operation and in 1939 published as Information Circular 7077 entitled Mining and Milling Methods and Costs at the Tennessee-Schuylkill Corporation Mine, Chloride, Arizona by Jacob Schrader.

Based on recoveries effected at the Arizona Bureau of Mines and on present marketing contracts for lead and zinc concentrates, there is little if any profit in processing the Tennessee tailing dump for lead and zinc concentrates alone using only conventional flotation methods. It is interesting to note that 51.8 percent of the tailing passed through a 325 mesh screen and this 51.8 percent of the tailing contained 63.2 percent of the zinc which represents an increase in value of 22.6 percent with respect to the total sample.

Since zinc has value as a plant nutrient, the minus 325 mesh material in the Tennessee-Schuylkill tailing should be examined with this use in mind, or as a filler for insecticide.

Inquiries were made at the U. S. Bureau of Mines Metallurgy Division relating to leach tests on lead-zinc ores. Various tests are being conducted presently, but on ores or concentrates containing not less than 10 percent combined metals. It would seem that further testing could be justified on tailing where all mining, crushing and grinding costs have been written off and an estimated 20 pounds of zinc per ton remain in the tailing. The current market price is 37 cents per pound.

It is estimated today that a 100-ton selective flotation plant to recover values from complex ores can be operated at a total cost of approximately ten dollars per ton of ore, broken down as follows: Crushing $1.50 per ton, grinding $2.50 per ton and flotation and miscellaneous at $6.00 per ton. Loading costs of mine dumps in the Cerbat Range are estimated at seventy-five cents per ton and hauling or transportation costs at fifteen cents per ton mile.

Although this project has shown that ores of commercial grade are in dumps with significant tonnages in the Cerbat Mountains based on present economic conditions, it must be remembered that the most reliable method for sampling mine dumps is bulk sampling. Time and cost restrictions placed on this project permitted us to sample only a few dumps and none by the bulk sampling method.

HISTORY

The Arizona Department of Mineral Resources during the first half of 1975 assisted and cooperated with the Kingman Section of the Arizona Small Mine Operators Association in attempting to gather factual data to attract investment capital to construct and operate a custom mill in Mohave County. The project was never completed.

Donald Aldridge of the Mohave County Board of Supervisors became interested in the project to stimulate economic activity in the county. A consulting firm was hired to make a preliminary, cursory examination to determine the feasibility of a custom mill in Mohave County. A statement unsupported by factual data was mailed to the Mohave County Board of Supervisors on October 15, 1975, in which a second phase was recommended of in-depth feasibility studies of individual properties to establish tenor and tonnages of available ores. The statement reads in part: "The initial phase of the resource study suggests that there would be numerous ore-shippers who would supply sufficient ore for processing over a period of approximately two years. Indications are such that ore shipment would continue over a much longer period once a custom mill was established."

The county, with assistance from ADMR, developed a program to proceed on the development of a viable mining library of descriptions of mines and mineral deposits in Mohave County, and then a short sampling program in a small area of the county for the purpose of soliciting Federal funds for the project. The proposed mining study was submitted in December, 1975. See Appendix A. The project was approved by State and Federal governments in March, 1976, and three people were hired April 7, 1976.

Reports dealing with Mohave County mines were copied from the ADMR files in Phoenix and transported to Kingman. Reports were solicited from governmental agencies and private parties.

PROJECT PLAN OF OPERATION

A simple indexed card system was set up with two separate alphabetic cards for each property:

- A card by owner's last name, address and name of mine or claim;
- B card by mine or claim name showing location, owner, metal or minerals produced and references to literature or reports.

A three-color code system was established for classifying the reports. Each mine file was studied and a decision made as to whether it should be coded red, green or yellow. Red meant that the file contained evidence of positive ore reserves in mine dumps or tailing ponds; Green code meant that the file contained indications of other types of ore reserves, showed outstanding production, contained current sampling data and assays, mentioned mill ore in dumps, etc., or needed additional literature research; a yellow tag meant that the property had nothing of interest to the project unless additional data appeared. Appendix B is an alphabetic listing of all the mining properties in Mohave County for which each file was reviewed. There are over 550 properties listed.

Current ownership and address for each property of interest was gleaned from courthouse records in the county assessor, treasurer and recorder offices and talking to old-timers in the various mining districts.

Follow-up work showed that the original color code classification had led to some inaccuracies in names, addresses, and in some instances reserve classification. Changes were made as knowledge was developed.

A form letter (Appendix C) was drafted to solicit permission from mine owners to enter and sample. There were only two mine owners who did not want dumps on their properties sampled or examined.

A student was hired by the County to assist in sorting, repairing and indexing a large number of mine maps for Mohave County properties purchased a number of years ago by Mohave County Board of Supervisors from the Ross Householder estate. Appendix D contains an alphabetical listing of 603 maps by mine, claim or company name or by district or area name. The type of map also is indicated and the location map rack number is shown. In addition, copies of mineral survey plats for a large number of mining claims which may or may not be patented have been assembled in the mining library (Appendix E).

SAMPLING PROCEDURE

A sampling procedure was worked out for mine dumps. Because of lack of adequate crushing equipment, all plus two-inch material was discarded (See Appendix F). Likewise, a procedure for sampling tailing was developed (See Appendix F). A hand auger was used to remove samples from tailing ponds. It was made especially for this use and is pictured in Figure 1.

SELECTION OF TARGET AREA

Preliminary paper reconnaissance was completed by the week of June 20, 1976 and the Cerbat Mountains northwest of Kingman were selected as the target area for a small, concentrated dump and tailing sampling project for a number of reasons:

(1) The literature search indicated that dumps and tailing ponds were relatively large and reports of sampling indicated significant values in both tailing and mine dumps predominantly in silver and zinc along with gold, lead and copper in varying amounts.

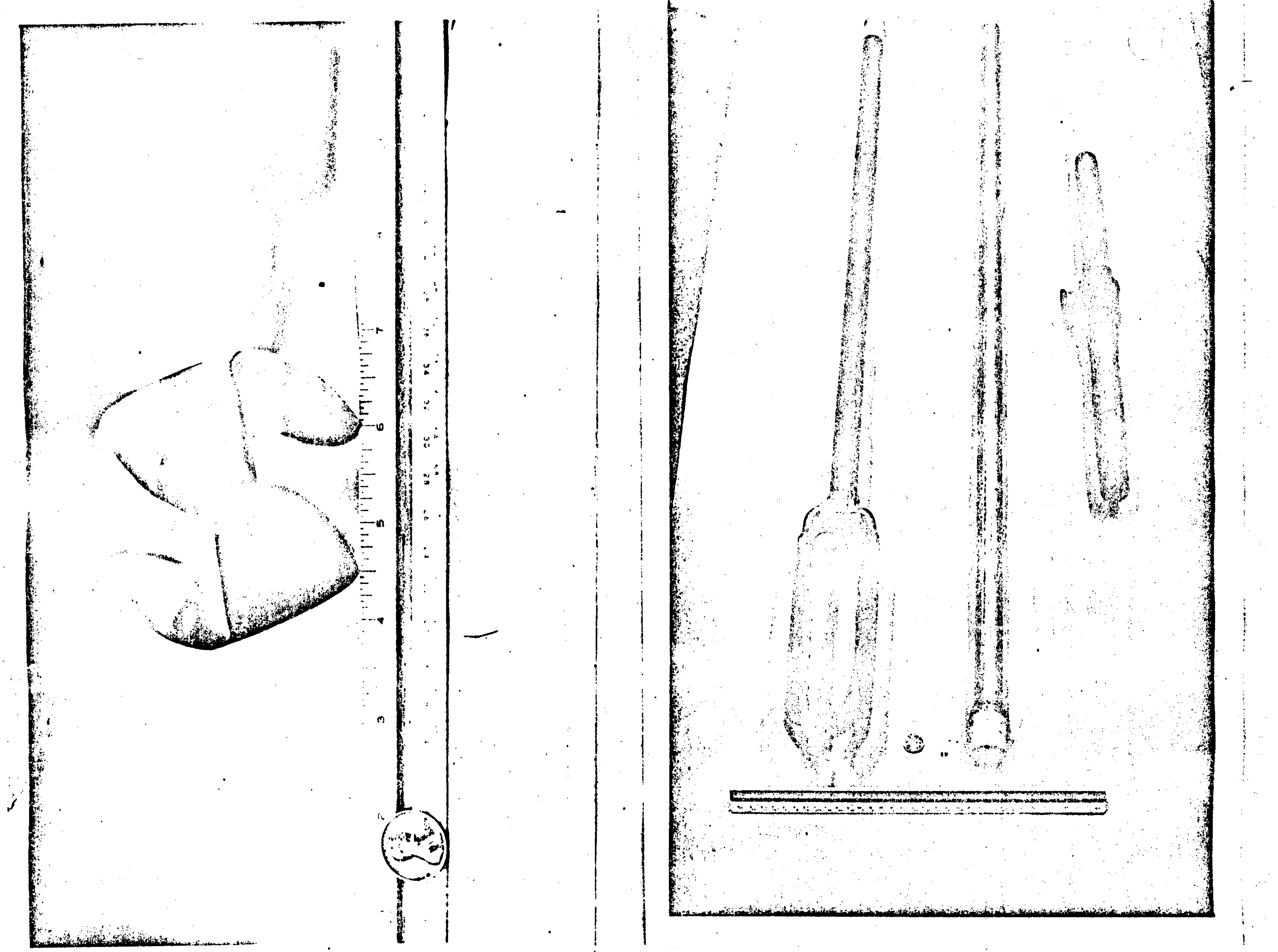


FIGURE #1

(2) Hauling distances from mines to a centrally located mill in any one of at least three locations would be less than ten miles.

(3) There were ample water reserves in the area for a 500 ton milling operation.

(4) Material supplies from Kingman and access to markets via Santa Fe Railroad in Kingman were more favorable than anyplace else in the county.

(5) Last but certainly very important, costs of the sampling project in this area close to Kingman would be less than for any other mining district in Mohave County.

It should be pointed out that the Arizona Department of Mineral Resources cooperated in this project at the specific request of the Mohave County Board of Supervisors and specific Arizona legislative delegates representing Mohave County. The Senior Author believed at the start of this project and more strongly than ever now, that a number of areas exist in Arizona where a half dozen or more small mineral deposits can supply ore at a profit to a centrally located mill where the mineral deposit at one mine alone would be too small to amortize a mill. It seemed apparent that economic conditions relating to complex ores had changed to the extent that a number of former waste dumps were now ore reserves. Surface loading costs are very minimal compared to costs of mining and transporting ore from an underground heading to the surface. Lead ores shipped direct to a lead smelter were penalized for contained zinc content. Hence, zinc ores were found discarded in a number of dumps.

Preliminary samples were obtained from the dumps and tailing ponds before a full scale sampling project was undertaken. Sufficient mineralization was observed in at least two dumps to make preliminary sampling unnecessary.

The following Table 1 shows those tailing ponds and mine dumps from which preliminary samples were taken. Some tailing ponds were found to contain insufficient values for a sampling project. This does not mean that the tailing at these locations will not be valuable for those assayed minerals or for other minerals under other conditions now or any time in the future.

Table

Results of Preliminary Samples

Mine	Type of Material	Type of Sample	Depth of hole in feet	Troy Ounces per short ton Au	Ag	Assay Percent Cu	Pb	Zn
Tennessee	Jig tailing Top of dump	Random grab		.011	0.45	0.05	0.57	1.01
Tennessee	Jig tailing Slope of dump	Random grab		.001	0.32	0.03	0.23	0.73
Arizona Magma	Tailing	Auger	0-11.2	.001	0.13	0.01	-	-
			11.2-15.6	.022	0.35	0.01	0.02	0.26
Cupel	Tailing	Auger	7.4	.006	0.95		0.65	
Pilgrim-Producers	Upper Tailing	Auger	0-15.3	.013	0.60	-	-	-
Pilgrim-Producers	Middle Tailing	Auger	0-20.0	.021	0.42	-	-	-
Pilgrim-Producers	Lower Tailing	Auger	0- 9.2	.014	0.54	-	-	-
Copper Age	Ore Pile	Hand Trench		.009	1.66	0.09	1.75	1.40
South Schuylkill	Mine Dump	Random grab		.028	0.75	0.02	0.85	0.29
North Schuylkill	Mine Dump	Random grab		.051	1.20	0.04	2.24	0.32
North Schuylkill	Mine Dump	Random grab		.136	0.67	0.02	0.38	0.33

Table I (continued)

Results of Preliminary Samples

Mine	Type of Material	Type of Sample	Depth of hole in feet	Troy ounces per short ton Au	Troy ounces per short ton Ag	Assay Percent Cu	Assay Percent Pb	Assay Percent Zn
Elkhart	Mine Dump	Random grab		.041	1.32	0.04	3.06	0.49
Elkhart	Mine Dump	Random grab		.056	2.36	0.05	3.20	0.47
Emerald Isle	Tailing (leached)	Auger	0-1.0			0.23		
			1.0-11.0			0.20		
			11.0-20.0			0.23		
		Auger	0-20.0	.007	0.16	0.23		

Table 2 shows the names of mines sampled, the type or kind and estimated tons of ore reserve which was sampled, and the weighted average assays. Computations, sections, work maps, etc. may be examined at the Mohave County minerals library in Kingman. All figures are subject to change pending a check of all sectional measurements and computations. A volume of 19 cubic feet per ton of tailing in place was used for computation of the Tennessee tailing dump to convert cubic feet to tons. Mine dump material was weighed and measured to determine conversion factors. (See Appendix D). Original surfaces below all dumps and tailing ponds were unknown quantities. Even so, the Senior Author believes that an accuracy of plus or minus 20 percent can be relied on.

In most instances mine dump samples were taken from excavated ditches at least two feet deep in the dump. This appeared to be the most reasonable method under the time-expense limitations imposed on the project. Ditches were excavated with a backhoe owned by the County. Wherever possible, the ditches were laid out on the dump surface in the direction that the original mine dump was deposited. (See Figure 2)

Appendix H contains maps and sample locations of all dumps and tailing ponds which were sampled. Each map contains respective elevations and a table of assays so that the individual reader may determine volume - assay of any part of any dump. Transit stations probably can be recovered in the field. A piece of pipe or steel rod was used to locate the station.

METALLURGY

Samples for metallurgical testing were collected for the Arizona Bureau of Mines from the Tennessee tailing pond. Sample number 1 was from a hole augered between holes B-1 and B-2 but not shown on the map, and sample number 2 was from hole number A-3. (See Appendix H) Following are the metallurgical results of flotation tests made by Sam Rudy of the Bureau.

Two samples were tested in the Arizona Bureau of Mines Laboratory. Sample one was delivered to the laboratory in late July. Sample two was given to representatives of the Bureau at the Tennessee-Schuylkill tailing site in mid-August. Both samples were obtained by making a vertical auger cut from the top of the dump to the original ground surface. Sample one was cut from near the center of the dump and sample two was cut between the center and the north periphery of the dump. Prior to testing, both samples were dried, weighed, and split into representative 1000 gram test packets. Representative fractions were also split out for chemical analysis, mineralogical examination and screen analysis.

Flotation tests were conducted in a procedure consistant with standard froth flotation practice for the recovery of sphalerite from pyritic ores. In general, the procedure was as follows. One thousand grams of tailing was attrited at 70% solids with tap water for five minutes in a Denver D-1 laboratory flotation cell. The pulp was diluted to 35% solids and suitable additions of the indicated reagents were added. The diluted pulp was conditioned for five minutes, air was introduced and froth was drawn for 12

Table

Measured and Sampled Reserves during July-October, 1976
in the Cerbat Mountains, Arizona

Mine	Type of Reserve	Estimated Short Tons	Assay: Troy Ounces per ton Au	Ag	Percent Cu	Pb	Zn
Minnesota-Connors	Mine dump and jig tailing	2000	.063	6.63	0.15	0.40	1.38
	Mine dump	1900	.025	4.58	0.16	0.13	0.82
	Mine dump	1100	.018	3.44	0.09	0.39	1.14
	Total	5000					
Payroll	Mine dump	1500	.103	2 50	0.09	1.79	1.64
Payroll	Mine dump	2000	.020	0.92	0.08	0.35	0.52
Elkhart	Mine dump	3000	.059	0.94	0.04	1.73	0.50
Schuylkill	Mine dump	500	.025	0.66	0.03	0.84	0.61
Roosevelt	Minus 3/4" leached tailing	22,000	-	-	0.39	-	-
Tennessee	Tailing	217,000	.012	0.33	0.03	0.19	1.01
Copper Age (vein 2.4 feet wide)	Underground blocked	4,200	.031	2.26		1.50	3.05
	Underground probable	1,500	.035	3.24		1.62	3.56
Total Measured Reserves		256,700					

minutes. Rougher froth was cleaned for 6 minutes and then recleaned for 4 minutes. Products from each test were filtered, dried, weighed and assayed. Metallurgical results were tabulated for each test and they are presented on the attached sheets.

The first laboratory considerations in the development work described in this memo were the determination of metal content, mineralogical associations, and size distribution of contained metal values. Table 3 gives the assay results obtained for the two tailing samples tested. Also listed, Item 3 is an average analysis from operating data at the Tennessee-Schuylkill mill for September, 1938.

Table 3

Metal Content of Tennessee-Schuylkill Tails

Identification			Assays		
	%Zn	%Pb	%Cu	OPT Ag	OPT Au
Sample 1	0.90	0.15	.02	0.15	0.005
Sample 2	1.56	0.15	.02	0.33	0.015
September, 1938	0.75	0.10	---	0.16	0.010

Examination of representative portions of Tennessee-Schuylkill tailings under the binocular microscope indicated most of the zinc was present as marmatite. Minor amounts of galena and arsenopyrite were also present with trace quantities of chalcopyrite. Pyrite was abundant and is reported to occur in two distinct forms; as well-defined, well-crystallized cubes with no gold, and as somewhat massive and fine-grained material containing from 0.3 to 15.0 ounces of gold per ton. The distinction between these two types was not obvious in the tailings samples examined. The primary gangue material was quartz. The presence of marmatite normally indicates recovery problems and decreases the tenor of zinc concentrates.

Table 4 illustrates the distribution of zinc throughout the tailing and gives a size distribution of one of the tailing samples tested.

Table 4

Distribution of Zinc in Sample One

Mesh Size	Wt. %	%Zinc	% Distribution
+48	2.5	.30	0.8
-48+65	6.4	.31	2.1
-65+100	11.0	.54	6.4
-100+200	16.0	.82	18.0
-200+325	12.3	.72	9.5
-325	51.8	1.14	63.2
	100.0	.93	100.0

Table 4 shows that over 63 percent of the zinc contained is finer than 325 mesh indicating that most of the zinc losses from the original mill treatment were associated with the slimes fraction. Microscopic examination of the tailings as well as the results of chemical analyses indicated that sufficient galena was not present to warrant a separate recovery circuit. Flotation experiments were thus directed at the recovery of marmatite and associated gold and silver values.

Zinc minerals are not usually amenable to flotation in their natural state. Flotation will not occur unless these minerals have been activated by one or more heavy metal salts, usually copper sulfate. Preliminary exploratory flotation tests indicated that some of the marmatite and a good part of the pyrite, especially in tailings sample two, were activated because of their history. Lime was used to adjust the pH to between 9 and 9.5 in rougher flotation, and between 11.2 and 11.5 in cleaning and recleaning to reject as much pyrite as possible. Exploratory testing also indicated that the use of a strong collector such as potassium amyl xanthate or dodecyl mercaptan significantly lowered concentrate grade by floating barren pyrite. Consequently, data were generated for the two tailings samples tested using a much more selective collector combination consisting of potassium ethyl xanthate and sodium aerofloat. Methyl iso-butyl carbanol was used as the frothing agent.

Table 5 shows comparative metallurgical data generated using the above described reagents and procedure. Detailed descriptions of the flotation tests are presented on the attached sheets.

Table 5

Metallurgical Summary for Tennessee-Schuylkill Tailing Flotation Tests

Sample No.	Concentration Ratio	Grade Zinc Recleaner Con. %Zn	OPT au	OPT Ag	% Recovery into Recleaner Con. Zn	Au	Ag
1	98	34.6	.122	3.20	37.0	18.1	10.9
2	267	29.1	----	----	6.9	----	----

Sample one responded much better than did sample two. However, a salable product could not be generated from either under the conditions tested. Recleaner concentrate contained substantial quantities of pyrite both free and intimately associated with marmatite. In the case of sample one, it is possible that further treatment including regrinding and reflotation could yield a higher grade concentrate with a corresponding reduction in overall zinc recovery. In the case of sample two, it does not appear that further treatment would be economically justified under any circumstance.

Based on the results of these preliminary flotation tests, it appears that a range of from 7 to 37% of the zinc contained in the Tennessee-Schuylkill tailings can be recovered in a concentrate containing from 29 to 35% zinc by standard flotation treatment. It also appears that about 20% of the gold and 10% of the silver will report in the zinc concentrate. Recovery of zinc, silver and gold from these tailings does not appear to be economically attractive at this point.

UNIVERSITY OF ARIZONA

ARIZONA BUREAU OF MINES

ORE TESTING SERVICE

Ore No. 1 (Sample One)   Test No. Tennessee-Schuylkill Tails

Conditions and Reagents

Point of Addition	Conditions			Reagents Pounds Per Ton								
	Time Mins.	% Solids	pH	$CuSO_4$	$Ca(OH)_2$	Z-3	NaAF	MIBC				
Attrition	5	70	6.2	-	-	-	-	-				
Condition	5	35	9.0	1.0	4.0	.05	.10	.05				
Rougher Flotation	12	-	9.0	-	-	-	-	-				
Cleaner Flotation	6	-	11.2	-	2.0	-	-	-				
Recleaner Flotation	4	-	11.5	-	2.0	-	-	-				

Remarks: Pulp slimy and viscous. Some pyrite present in rougher froth with marmatite. Good froth. Some marmatite fell out in cleaning. Some pyrite present in recleaner concentrate. May need to regrind recleaner conc. and refloat.

Metallurgical Products

Product	Tons in 100 Tons Feed	Assays						% of Total				
		Zn	Au	Ag				Zn	Au	Ag		
Re. Cl. Con.	1.02	34.60	.122	3.20				37.0	18.1	10.9		
Re. Cl. Tail	1.17	9.95	.088	2.09				12.2	15.0	8.2		
Cl. Tail	5.62	.75	.016	.38				4.4	13.1	7.1		
Ro. Tail	92.19	.48	.004	.24				46.4	53.8	73.8		
Calc. Hd.		.95	.007	.30				100	100	100		

Remarks: Sample one responded much better than did sample two.

UNIVERSITY OF ARIZONA
ARIZONA BUREAU OF MINES
ORE TESTING SERVICE

Ore No. 2 (Sample Two) **Test No.** Tennessee-Schuylkill Tails

Conditions and Reagents

Point of Addition	Conditions			Reagents Pounds Per Ton									
	Time Mins.	% Solids	pH	$CuSO_4$	$Ca(OH)_2$	Z-3	NaAF	MIBC					
Attrition	5	70	5.3	--	--	--	--	--					
Condition	5	35	9.3	1.0	7.0	.05	.10	.05					
Rougher Flotation	12	--	---	--	--	--	--	--					
Cleaner Flotation	6	--	11.5	--	2.0	--	--	--					
Recleaner Flotation	4	--	11.5	--	2.0	--	--	--					

Remarks: Pulp slimy and viscous. Large quantity of pyrite present in rougher froth. Minor quantity of marmatite present. More lime required than in test 1 to obtain proper pH. Much pyrite in cleaner and recleaner concentrate.

Metallurgical Products

Product	Tons in 100 Tons Feed	Assays					% of Total				
		Zn					Zn				
Re. Cl. Con.	0.37	29.10					6.9				
Re. Cl. Tail	3.08	5.20					10.2				
Cl. Tail	8.51	2.13					11.6				
Ro. Tail	88.03	1.27					71.3				
Calc. Hd.		1.57									

Remarks: Very poor response to flotation. Zinc appears to be associated with pyrite. Try cyanide to assist in pyrite depression.

Table 6 shows significant tonnages in the Cerbat Mountains which were not sampled by project personnel. Source data may be examined as cited in footnotes of the table.

Something should be said about uranium occurrences in complex ores in the Cerbat Range. The United States Atomic Energy Commission in June, 1953, published RME-4026 titled Preliminary Report on Uranium-Bearing Deposits in Mohave County, Arizona by Olin M. Hart and D. L. Hetland. Copies of this report may be examined either at the Mohave County minerals library or at the Department of Mineral Resources in Phoenix. Of eight properties described, six are in the Cerbat Mountain Range. There are descriptions of the Detroit Group, De La Fontaine Mine, Prosperity and Primrose claims (both a part of the Golconda Property), Bobtail Mine and the Lower Summit Mine. According to the report: "The uranium minerals occur in veins containing predominantly sphalerite, with usually some galena, along with varying amounts of quartz, pyrite, arsenopyrite and limonite".

Samples were collected from the Detroit mine probably during 1956 for metallurgical testing of ores containing uranium minerals, presumably under an AEC research project. The samples were shipped to the Mackay School of Mines at Reno, Nevada and to Massachusetts Institute of Technology at Cambridge, Massachusetts. Responses to inquiries to both institutions indicated that no tests were conducted at either of the institutions. It is reported that a report by Atomic Energy Commission titled RME 3142 Investigation of the Amount and Distribution of Uranium in Sulfide Minerals in Vein Ore Deposits (Annual Report for 7/1/55 to 3/31/56) discusses ores in the Wallapi Mining District. The Authors have not seen this report.

Reports in files indicate that some of the complex ores in the Cerbat Range carry small amounts of Indium and Germanium.

The Department of Mineral Resources is no longer associated with the Project, except in an advisory capacity. The Mine Study, under sole authority of the Mohave County Board of Supervisors, continues to compile information, from any source it can get about mines, prospects, or exploration activities in Mohave County. The files are available to the public for in-office use between the hours of 8:00 a.m. and 5:00 p.m., Monday through Friday, at the County Annex Building in Kingman.

There are thousands of prospects and hundreds of small mines in the various mining districts of Mohave County. It is not possible to get total information or to examine every mine or prospect. The study will appreciate any type of information that anyone has to offer, about mining, geology etc. in Mohave County. Although much of the information is from previously existing maps and reports, there is included some recent data. It is known that similar studies have been conducted by various firms and individuals, however much of this information is not available to the public. Duplicate copies of reports may be obtained upon request at a nominal fee. Some of the information would also be of interest to students, writers, historians, and others. Many of the maps are too large to be duplicated by the Department's present equipment. Eventually the maps will be placed so that

Table 5

Ore Reserves in the Cerbat Mountains,
Arizona, from cited sources

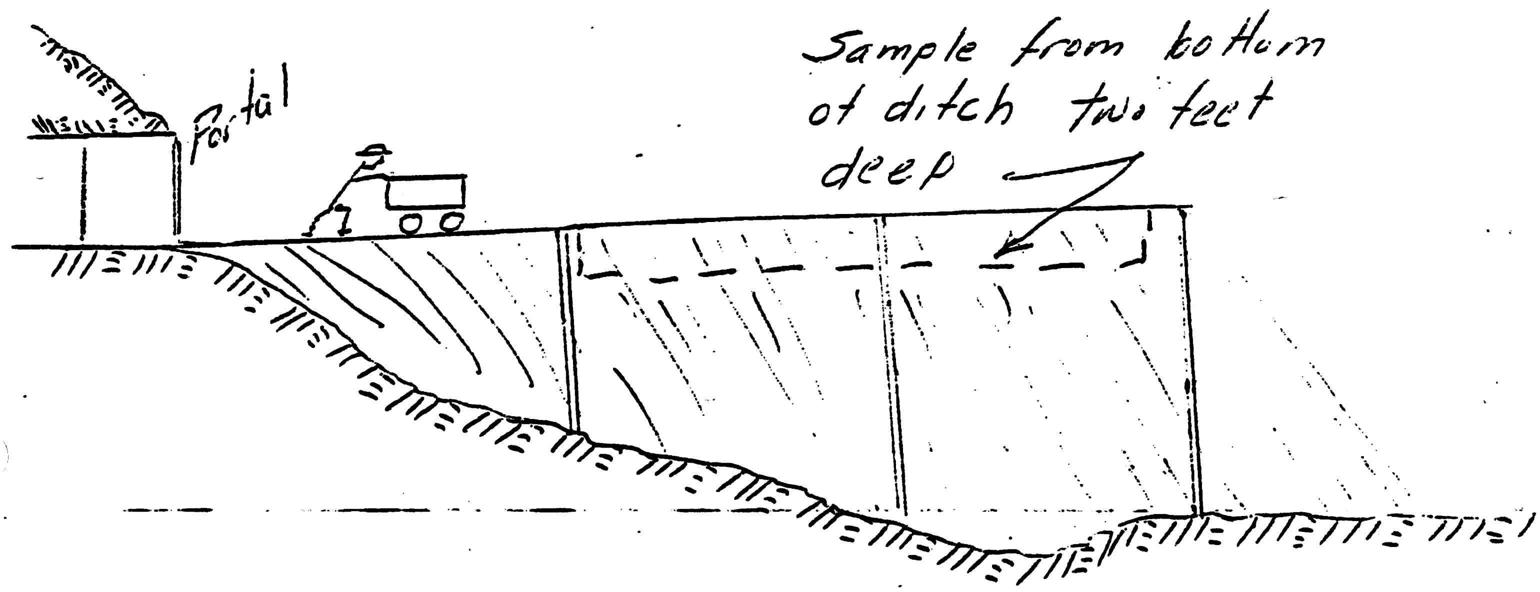
Name of Mine	Type of Reserve	Estimated Short Tons	Assay: Troy Ounces per ton Au	Ag	Percent Cu	Pb	Zn
Juno 1/	Mine dump	50,000	0.03	2.0		<1.0	
Hercules-Badger 1/	Mine dump	25,000	0.05	3.0		>2.0	
COD 2/	Mine dump	3,000	0.14	7.90	0.50	1.25	3.89
	Mine dump	3,500	not known				
	Tailing	4,000	0.12	3.74		0.29	1.25
		10,500					
Golconda 3/	Mine dumps	60,000	not known				
	Mine dump	40,000	0.09	1.6	0.3	0.5	5.3
	Jig tailing	50,000	0.09	1.3	0.2	0.62	6.08
	Table tailing	25,000	not known				
	Total Tons	260,500					

1/ Written and oral communication from Richard V. Wyman, President Intermountain Exploration Company, Box 473, Boulder City, Nevada, 89005.

2/ Private report

3/ Private reports in mine file in Mohave County Mining Library and in Phoenix DMR files tracings, or copies from microfilm can be made available at a reasonable fee. Neither the County nor the project will be involved in any type of mining or milling venture.

The Mine Study welcomes all constructive criticisms and suggestions. If there is something you would like to express about the Mine Study, please write to the Mohave County Board of Supervisors.



DUMP SAMPLING METHOD

Figure 2

MOHAVE COUNTY BOARD of SUPERVISORS

P.O. BOX 390 • KINGMAN • ARIZONA 86401

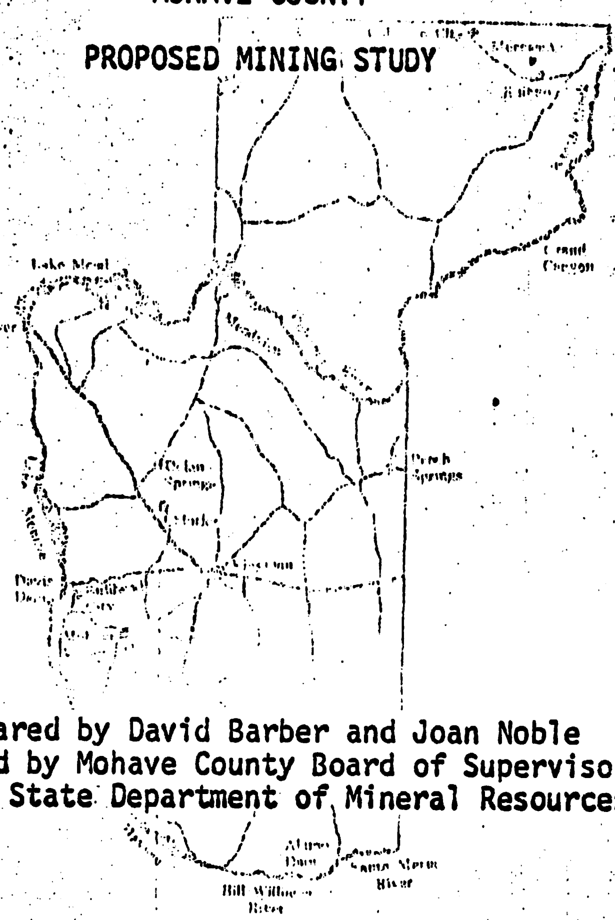
SUPERVISOR
Donald R. Aldridge
District 1

SUPERVISOR
James H. Howell D.D.S.
District 2

SUPERVISOR
W. B. Ketchner O.D.
District 3

MOHAVE COUNTY

PROPOSED MINING STUDY



Prepared by David Barber and Joan Noble
Supported by Mohave County Board of Supervisors
and the State Department of Mineral Resources

December, 1975

OUTLINE

INTRODUCTION

Due to the large number of inquiries from interested individuals, it has prompted the Mohave County Board of Supervisors to investigate the use of CETA funds to conduct a mining study. Currently there are no custom mills in operation in Northern Arizona. It is well worth noting no private industry has ever conducted a similar study such as this. For these three reasons the Board of Supervisors feels this study would stimulate the mining economy in Mohave County and the State of Arizona.

The State Department of Mineral Resources stated Mohave County has the leading potential for mining in Arizona. This statement has been based on the recent filing of claim notices. (See Appendix.) In addition, the State Department of Mineral Resources stated the results of this study has a great probability of stimulating the employment and indirectly the economy of trucking companies, utilities companies, housing, small businesses and individual miners.

It should also be noted a custom mill operation does not pollute the air or water. All water is recycled through the operation, preventing any waste. This indicates a mining and custom mill operation in Mohave County would be compatible with the environment.

PURPOSE

The purpose of this detailed mining study is to determine the ore reserves for lead, zinc, copper, gold and silver. The staff plans to accumulate mining data on Mohave County into a unified study. This information shall provide a valuable tool in assessing the feasibility for locating a custom mill operation in Mohave County.

PROCEDURE

Mr. John Jett, the Director of the State Department of Mineral Resources, has volunteered Mr. Vernon Dale's time to coordinate this detailed mining study. Mr. Dale is registered in the State of Arizona as a mining engineer and is a highly qualified professional engineer. Mr. Dale shall spend approximately half of his time working on this study.

The study will require three semi-professional technicians. The staff may consist of college students from one of the State Universities. This shall provide valuable work experience which will assist these persons in obtaining permanent employment. However, if college students cannot be obtained, the Mohave County Board of Supervisors desires the option to select additional semi-professional personnel.

Six months shall be required to complete this mining study. Throughout the six month period, the staff shall gather data which is required to conduct this thorough investigation. Various individuals have investigated several mines in Mohave County, however, accumulation of this information has never been undertaken.

EXPENDITURES

In kind contribution from the State Department of Mineral Resources (registered State mining engineer, 6 months).

	Mining Engineer	$12,000
1. Travel expenses for State mining engineer 12 trips at $100/trip:	Travel	1,200
2. Per diem for Engineer: $30/day 125 days x $30	Per Diem	3,750

EXPENDITURES (Cont'd)

$ 6.00	Dinner
3.50	Lunch
2.50	Breakfast
18.00	Room
$30.00	

STAFF

3.	3 Technical Assistants: $536/Month		
	$536 x 1.15 (F.B.) = $616 x 3 men = $1848/Month		
	$1848 x 6 months	Staff	$11,088
4.	Staff expenses $30/day		
	80 days x $30	Per Diem	2,400
5.	Travel expense $.15/Mile	Travel	2,000
6.	Administrative Expense		
	Telephone, paper, zerox, checkwriting, etc.	Administrative Expense	2,000
7.	Total Expenditures for Detailed Mining Study		$22,438

The Mohave County Board of Supervisors requests flexibility with these funds.

EXPECTED RESULTS

The expected results shall stimulate the economy of Mohave County. A custom mill will require between eight and ten persons to operate the mill effectively. The State Department of Mineral Resources estimates approximately 30 or 40 small mine operators will use the custom mill facility if located in Mohave County. A small mine operation requires two or three persons to produce ore for processing in the custom mill.

EXPECTED RESULTS (Cont'd)

In addition, transportation of ore to a custom mill for processing shall stimulate the trucking business. It is estimated approximately 150 persons have potential for employment if stimulation of the mining industry occurs. Since at the present time there is no custom mill in Northern Arizona, it is highly possible employment figures could run much higher.

SUMMARY

The Mohave County Board of Supervisors suggest the State Department of Mineral Resources be allowed to coordinate this mining study. Mohave County recommends the study be conducted as outlined in this proposal. The information obtained and the final study shall be made available to any person requesting information concerning mining in Mohave County.

FEB.2,1977

MOHAVE COUNTY MINE STUDY(Preliminary list)

CARD
FILE INDEX

MINE NAME	DISTRICT
ADAMS	SAN FRANCISCO
ADELA(KROOK MINE)	
AFRICAN	WHITE HILLS
ALAMO QUEEN	ARTILLERY MTS.
ALEXANDER GROUP	WALLAPAI
ALICE MINE	WALLAPAI
ALPHA MINE	WALLAPAI
ALTATA	WALLAPAI
AMERICAN FLAG	MAYNARD
ANTLER GOLD MINE	ARTILLERY
ANTLER GOLD MINE	CEDAR VALLEY
APACHE GROUP	SAN FRANCISCO
APACHE ORO CO.	LOST BASIN
ARABIAN	KATHERINE
ARIZONA MAGMA MINING CO.	WALLAPAI
ARIZONA-TOM REED GOLD MINES CO.	GOLD ROAD DIST.
ARK	WALLAPAI
ARMOUR GROUP	CERBAT
ARTILLERY PEAK	ARTILLERY MTNS. REGION
AURORA	WALLAPAI
AYRA	
BALD EAGLE	UNION PASS
BANNER FOUNTAINHEAD	CERBAT MOUTAINS
BANNER MINE	CERBAT
BANNER	UNION PASS
BARYTES COPPER CLAIMS	
BAY STATE	WALLAPAI
B.C. GROUP	CEDAR
BEAVER&MONTE CRISTO GROUPS	WALLAPAI
BEE BEE NO.1	SAN FRANCISCO
BERGER-PHILLIPS TUNGSTEN	GREENWOOD
BEST BET	MAYNARD
THE BEST BET orKEMPF	CHEMEHUEVIS
BETSY ROSS NO;1,2,3&4	OWENS
BIG BETHEL CLAIM	
BIG HORSE SHOE	MAYNARD
BIG JIM	SAN FRANCISCO
BIG LEDGE#1,2,3,4	COTTONWOOD
BIG TENNESSEE MINING CO.	
BILLY BRYAN	GOLD ROAD
BIMETAL	MC CONNICO
BISMARK GROUP	WALLAPAI
BLACK BURRO	
BLACK CROW	ARTILLERY MTS.
BLACK DIAMOND GROUP	ARTILLERY PEAK
BLACK DIAMOND PROPERTY	
BLACK DYKE	WILLIAMS
BLACK EAGLE GROUP	ARTILLERY MTS.
BLACK HAWK,SUNSET,GREENBURG& BLUE JAY	SIGNAL

MINE NAME	DISTRICT
BLACK MARY	ARTILLERY MTS.
BLACK JACK GROUP	ARTILLERY MTS.
BLACK MOLLIE	ARTILLERY MTS.
BLACK PRINCE PROSPECT	
BLACK RANGE MINE	SAN FRANCISCO
BLACK WARRIOR	ARTILLERY MTS.
BLACK WONDER GROUP	SAN FRANCISCO
BLOSSOM GROUP	ARTILLERY MTS.
BLUE BELL	WALLAPAI
BLUE BIRD PROPERTY (Mohawk&Mohawk Ext.)	SAN FRANCISCO
BLUE RIDGE HOME LODE	SAN FRANCISCO
BLUESTONE CLAIM	
BOBBIE BURNS GROUP	CHLORIDE
BOBTAIL	WALLAPAI
BONANZA	SAN FRANCISCO
THE BOOBY&MOHAWK	WALLAPAI
BORIANA	MAYNARD
BOULDER CREEK GROUP	McCONNICO
BREWER&MILLER	MAYNARD
BRIGHTER DAYS	
BROOKLYN	MAYNARD
BRYAN	WHITE HILLS
BUCKEYE	WALLAPAI
BUCKHORN	COTTONWOOD
BULL CANYON TUNGSTEN	CEDAR
BUNKER HILL	WALLAPAI
BURRO CREEK	GREENWOOD
BURROWS	EL DORADO PASS
CABIN	WALLAPAI
CANDY BAR GROUP	
CARR	MAYNARD
CARROW PROSPECT	
CARTER GROUP	SAN FRANCISCO
CASEY JONES GROUP	TOM REED GOLD ROAD
CASH ENTRY GROUP	SAN FRANCISCO
CASHIER	WALLAPAI
CASTENADA GROUP	
CATHERINE&MICHAEL CLAIMS	
CEDAR GROUP	CEDAR VALLEY
CENTENNIEL	OWENS
CENTURY	MAYNARD
CENTURY	MAYNARD
CERBAT	
CHAMPION	WALLAPAI
CHAPEL CLAIM	MULE CANYON
CHEMEHUEVIS PLACERS	GOLD WING
CHICAGO GROUP	
CHIEF OF THE HILLS	WHITE HILLS
CHOLLA(PLACERS)	SAN FRANCISCO
CISCO	
CLARK&LYNN CLAIMS	MAYNARD
CLEOPATRA	OWENS
CLIMAE	MAYNARD

MINE NAME	DISTRICT
CLIMAX	SAN FRANCISCO
C.O.D.	WALLAPAI
MARY COLOMA GOLD MINING CO.	SAN FRANCISCO
COLORADO,COLORADO 1,2,3,4,5	LOST BASIN
COLUMBUS LEAD CARBONATE	MAYNARD
COLUMBUS-MONROE DOCTRINE	WALLAPAI
COMBINATION FRACTION CLAIM	OATMAN
COMSTOCK GROUP	SAN FRANCISCO
CONFIDENCE	OWENS
CONSOLIDATED GOLD MINING CO.	
CONSOLIDATED TUNGSTEN	
COPPER AGE	
COPPER APEX	WALLAPAI
COPPER BASIN MILL	CIENEGA
COPPER CLIFF	OWENS
COPPER GIANT	HACKBERRY
COPPER HEAD MILL	
COPPEROPOLIS	WALLAPAI
COPPER OSTRICH,HOME PASTIME	WALLAPAI
COPPERVILLE PROP.	
COPPERWORLD	CEDAR VALLEY #43
CORNWALL,GOLD STAR	WALLAPAI
CUNNINGHAM	BENTLEY
CUPEL	
CURRY&ALEXANDER GROUP	SAN FRANCISCO
CYCLOPIC	GOLD BASIN
DAB NO. 1&DAGMAR	
DAB NO. 1	
DANDY GROUP	WEAVER
DEER TRAIL	
DE LA FOUNTAINE	STOCKTON HILL
DELTA GROUP	
DELEWARE	MOJAVE
DELTA&MAGGIE CLAIMS	
DEMOCRAT	MAYNARD
DETROIT	WALLAPAI
DIAMOND JOE	
DIPLOMAT	WALLAPAI
DISTAFF	CHLORIDE
DIXIE QUEEN	WEAVER
DOLLY VARDEN	MAYNARD
DOME MINING GROUP	SAN FRANCISCO
DOYLE VANADIUM OR DOYLE MINING CO.	OWENS
DREAMER NOS.1-39	
DUNGAN TUNGSTEN	GREENWOOD
EAGLE	CERBAT
EL DORADO	
EL DORADO	GOLD BASIN
ELKHART	WALLAPAI
ELLEN JANE	MUSIC MTN.
EL ORO (FORMERLY COPPER AGE)	MINERAL PARK
EL SANTOS MINE GROUP	PEACOCK
EMERALD ISLE	WALLAPAI
EMERSON GROUP	WALLAPAI
EMPIRE	WALLAPAI

MINE NAME	DISTRICT
EMPIRE GROUP	MAYNARD
EMPIRE GROUP(EMPIRE#1,2,4)	GOLD ROAD
ENTERPRISE	MAYNARD
ESMERALDA	WALLAPAI
ESPERANZA	CEDAR VALLEY
ESPERANZA	OWENS
EUREKA CONSOLIDATED	WALLAPAI
EUREKA&EUREKA	WALLAPAI
EVAHOM CHARITY GROUP	WALLAPAI
EXTENSION GROUP	UNION PASS
FAIRFIELD	WALLAPAI
FLORES	WALLAPAI
FLYNN GROUP	MINNESOTA
FORTUNATUS	WALLAPAI
FOOT HILL	WALLAPAI
FREDONIA#1	
FREEMAN TUNGSTEN	GREENWOOD
FRISCO	KATHERINE
FRONTIER&FRONTIER#2	WALLAPAI
FRY	GOLD BASIN
GARFIELD	WHITE HILLS
GEDDIS-PERRY	SAN FRANCISCO
GEORGE GROUP	OWENS
GEORGE WASHINTON-SABBATH	MINERAL PARK BASIN
GILPIN MINE(A.K.A. TIMES)	SAN FRANCISCO
GLADIATOR,GLADIATOR 1-7	
GOLCONDA	WALLAPAI
GOLDEN AGE	WEAVER
GOLD BASIN	GOLD BASIN
GOLD BELT	GOLD BASIN
GOLD CHIEF GROUP	OWENS
GOLD CROWN	WEAVER
GOLDEN CYCLE	KATHERINE
GOLD DUST	SAN FRANCISCO
GOLDFLAT	MAYNARD(McCONNICO)
GOLD FLAT GROUP	INDIAN SECRET
GOLD HILL	GOLD BASIN
GOLD HILL,GOLD LEDGE&HILL	SAN FRANCISCO
GOLD KEY(AND TOM REED,JR.)	SAN FRANCISCO
GOLD KING	MAYNARD
GOLD MEDAL	MAYNARD
GOLD NUGGET	WALLAPAI
GOLD ORE	SAN FRANCISCO
GOLD RANGE	SAN FRANCISCO
GOLD REED	
GOLD ROAD	SAN FRANCISCO
GOLD ROAD	SAN FRANCISCO
GOLD ROAD ANNEX GROUP	GOLD ROAD
GOLDROAD BONANZA	SAN FRANCISCO
GOLDEN BULLET	WALLAPAI
GOLDEN DOOR	WEAVER
GOLDEN EAGLE	WALLAPAI
GOLDEN GATE	CHEMEHEUVIS
GOLDEN GEM	WALLAPAI

MINE NAME	DISTRICT
GOLDEN HAMMER	MINERAL PARK
GOLDEN HORN	WALLAPAI
GOLDEN JUNE	GOLD BASIN
GOLDEN LINK	WALLAPAI
GOLDEN RULE	GOLD BASIN
GOLDEN STAR GROUP	GOLD ROAD
GOLDEN STAR	
G.R. GROUP	WALLAPAI
GRAND ARMY OF THE REPUBLIC	WHITE HILLS
GRAND GULCH	BENTLEY
GRAND VIEW GROUP	WALLAPAI
GRAND VIEW&GRAND VIEW EXT.	BOULDER CANYON
GRAND VIEW GROUP	MAYNARD
GREAT BEND	INDIAN SECRET
GREAT EASTERN GROUP	MAYNARD
GREAT WEST	VIRGINIA
GROSS COPPER PROSPECTS	WALLAPAI
GUADALUPE CLAIMS	SAN FRANCISCO
HACK MILL	SAN FRANCISCO
HACKS CANYON	HACKS CANYON
HACKBERRY	PEACOCK
HAGEY MINING CLAIMS	WALLAPAI
HALL	VIRGINIA
HARDY	SAN FRANCISCO
H.E.C. PROSPECT	
H&H GROUP	CEDAR
HELEN GROUP	SAN FRANCISCO
HELEN#1,2	
HERCULES-BADGER GROUP	
HIVERNIA	MAYNARD
HIGH GRADE GROUP	MAYNARD
HIGHLAND CHIEF&MOUNTAIN BEAUTY PROP.	BOUNDARY CONE
HILLSIDE	MAYNARD
HOGUE GROUP	MUSIC MTN.
HOLY MOSES	McCONNICO SEC.(MAYNARD)
HOMESTAKE GROUP	SAN FRANCISCO
HOOVER GROUP	MINNESOTA
HORN SILVER CLAIMS	MINNESOTA
HORSESHOE CLAIMS	
HOT SPOT GROUP	
HUGHES ARIZONA COPPER CO.	CHLORIDE
IDAHO	WALLAPAI
IDAHO(IDAHO TUB)	WALLAPAI
INDIAN	ARTILLERY MTS.
IOWA GROUP	SAN FRANCISCO
IRON CLAD(CACTUS QUEEN)	OWENS
IRON DUKE GROUP	MUSIC MT.
I.X.L. MINES GROUP	STOCKTON HILL
JACK POT	MAYNARD
J.C. MINE	WALLAPAI
JEMISON MINES CO.	WALLAPAI
JESSIE BELL#2,3,4	MINNESOTA
J.F.T. MINE	WALLAPAI
JIM KANE	WALLAPAI
JOHNNY BULL-SIVER KNIGHT	WALLAPAI

MINE NAME	DISTRICT
JOSHUA GOLD	LOST BASIN
JUMBO WASH	
JUNO	WALLAPAI
JUROR #1&2	WALLAPAI
KAABA	MAYNARD
KAMPFF	CHEMEHUEVIS
KANSAS-CROWN KING GROUP	
KATHERINE	KATHERINE
KATIE	MINERAL PARK
KATY J. CLAIMS	
KAY COPPER	WALLAPAI
KEYSTONE	MINERAL PARK
KIM CLAIMS	
KING DAVID	MAYNARD
KING MIDAS GROUP	SAN FRANCISCO
KING OF SECRET PASS	SAN FRANCISCO
KING TUT PLACERS	LOST BASIN
KISTLER PROSPECT	
KLONDYKE	WEAVER
KRAUSS AND GOLDEN ERA PROPERTIES	BOUNDARY CONE
LADY BUG GROUP	WALLAPAI
LAKE DEP. OF CHAPIN GR.	ARTILLERY MTS.
LA PAZ	SAN FRANSISCO
LAST CHANCE	ARTILLERY MTS.
LAST CHANCE	MAYNARD
LAST MINUTE	TOPOCK
LAZY BOY	SAN FRANCISCO
LEAD BULLET	WALLAPAI
LEAD PILL	
LELAND	SAN FRANCISCO
LEOPARD SPOT GOLD MINE	SAN FRANSISCO
LEVIATHAN	
LEXINGTON ARIZONA MINING CO.	SAN FRANCISCO
LITTLE ANNIE-HORN GROUP	OATMAN
LITTLE BOY GROUP	WALLAPAI
LITTLE JIMMIE CLAIM	
LONE JACK#1&2	LOST BASIN
LITTLE KIMBLE GOLD	OWENS
LONE JACK-BLACKFOOT	WALLAPAI
LONE MOUNTAIN	
LONE STAR GROUP	ARTILLERY MTS.
LOOKOUT GROUP	MAYNARD
LOST PARTNERS	
LOST MINE	GREENWOOD
LUCKY BOY	WALLAPAI
LUCKY CUSS CLAIM	MUSIC MTS.
LUCKY FOUR PROPERTY	
LUCKY 44 CLAIMS	
LUCKY FRIDAY	WALLAPAI
LUCKY JOE	
LUCKY STRIKE	GOLD BASIN
LUCKY STRIKE	OWENS
M CLAIMS	MAYNARD (McCONNICO)
MADRILL LEAVIS TUNGSTEN	GREENWOOD

MINE NAME	DISTRICT
MAGGIE	ARTILLERY PEAK
MAHOGANY CLAIM	
MAMMOUTH NO.1	WALLAPAI
MANGANESE ORE	
MARIE E. VEIN	MUSIC MTN.
MARIETTA ET. AL CLAIMS	CHLORIDE
MARIPOSA	SAN FRANCISCO
MARY BELL	WALLAPAI
MARY NEVADA	MAYNARD
MASTERSON GROUP	
MEALS LEDGE	GOLD ROAD
MEALS MINING CO. PROPERTY	
MERRIMAC	WALLAPAI
MESA MANGANESE	
METALLIC ACCIDENT	
MEXICAN	CHLORIDE
MIDAS GROUP	CERBAT
MIDDAY CLAIM&NEARBY DEVELOPEMENT	
MIDDLE HACKBERRY	
MIDGET	LOST BASIN
MIDIS CLAIM	
MIDNIGHT GROUP	SAN FRANCISCO
MIDNIGHT	WALLAPAI
MIDWAY TUNGSTEN	CEDAR VALLEY
MIDWEST	OWENS
THE MILLER GROUP	SAN FRANCISCO
MINERAL"X"CLAIM	MAYNARD
MINERAL PARK	WALLAPAI
MINNESOTA CONNOR	WALLAPAI
MINT	MINERAL PARK
MOCKINGBIRD	N. BLACK MTS.
MOHAVE CHIEF	CHEMEHEUVIS
MOHAVE GROUP	
MOHAVE MIDNIGHT MINING CO.	WALLAPAI
MOHAWK MINE	MUSIC MTN.
MOHAWK	WALLAPAI
MOHAWK	
MOLLIE GIBSON	WALLAPAI
MOLYBDENUM	CEDAR VALLEY
MONITOR	CERBAT
MONTE CRISTO GROUP	
MOON MINE	MINERAL PARK
MORROW	OWENS
MOSS	OATMAN
MOSSBACK GROUP	OATMAN
MUSIC MOUNTAIN DIST. MINE	MUSIC MT.
McBRIDE	COTTONWOOD
McCRACKEN	OWENS
McGREGOR PROP.	ARTILLERY MTS.
McKESSON GROUP	McCONNICO
NANCY LEE	SECRET PASS
NAVICO GROUP#1	
NAVY GROUP	GOLD ROAD
NEEDLE EYE	ARTILLERY MTS.

MINE NAME	DISTRICT
NELLO GROUP	MAYNARD
NEST CLAIM	
NEVADA-ARIZONA MINES CO.	MUSIC MTN.
NEVER GET LEFT	GOLD BASIN
NEW ENGLAND GROUP	OWENS
NEW JERSEY	
NEW LONDON	WALLAPAI
NEW MOON	
NEW YORK&MANHATTAN	WALLAPAI
MICK LENTINE	
NIGHTHAWK	WALLAPAI
NOON TIME GROUP	SAN FRANCISCO
NORMA	WHITE HILLS
NORTH GEORGIA	WALLAPAI
NORTH STAR GROUP	SAN FRANCISCO
NORTH STAR #1&2 CLAIMS	COTTONWOOD
OATMAN CONSOLIDATED MINE CO.	GOLD ROAD
OATMAN FEDERAL MINES CO.	SAN FRANCISCO
OATMAN MINING AND MILLING	OATMAN
OATMAN MOHAWK MINING CO.	SAN FRANCISCO
OATMAN QUEEN GOLD MINING CO.	SAN FRANCISCO
OATMAN REVENUE	
O'BRIEN GROUP	WALLAPAI
OCCIDENT&HORN SILVER	WHITE HILLS
O'FALLON	WALLAPAI
O.K.&EXCELSIOR	
O.K. GROUP	UNION PASS
OLD HACKBERRY	MAYNARD
OLD 97	
OLD TIMER-SILVER COIN	
ONETTO GROUP	SAN FRANCISCO
ORION MNG&MILLING CO.	
ORO FINO GROUP	
ORO PLATA	MINERAL PARK
OXIDE	OWENS
OATMAN AMALGAMATED GOLD MINING CO.	SAN FRANCISCO
PAN AMERICAN	CENTRAL
PAYMASTER GROUP	WALLAPAI
PAY LODE CLAIM	CERBAT
PAY ROLL	WALLAPAI
PEACH TUNNEL	
PHILADELPHIA	UNION PASS
PHILLIPS TUNGSTEN	AQUARIUS REGION
PICTURED ROCK GOLD MINING CO.	SAN FRANCISCO
PILGRIM MINE	PILGRIM
PILOT ROCK	
PINKHAM	WALLAPAI
PIONEER OR GERMAN-AMERICAN	SAN FRANCISCO
PLANCHA MTS. GROUP	ARTILLERY MTS.
PLENDINA CLAIMS	
POCAHONTAS	VIRGINIA
POLANLTE GROUP	ARTILLERY MTS.
POPE MINE	MINNESOTA

MINE NAME	DISTRICT
PORTLAND MINE	KATHERINE
POST GROUP	SAN FRANCISCO
PRICE GROUP	ARTILLERY MTS.
PRICELESS GROUP	ARTILLERY MTS.
PRIMROSE	WALLAPAI
PRINCE ALBERT	WHITE HILLS
PRINCE GEORGE	
PROSPERITY	WALLAPAI
PSILOMELANE GROUP	ARTILLERY MTS.
PYRAMID	KATHERINE
QUEEN ANN GROUP 1-5	GOLD BASIN
QUEEN BEE	WALLAPAI
RACHEL CLAIMS	GOLD BASIN
RAINBOW	WALLAPAI
RAINY DAY CLAIMS	
RATTLESNAKE,PEACOCK&TRYANGLE	WALLAPAI
RAWHIDE	OWENS
REDEMPTION	WALLAPAI
RED GAP	WEAVER
RED HILLS	RAWHIDE
RED ROBIN	MINERAL PARK
RED TOP	
RIVER VIEW GROUP	OATMAN
ROADSIDE	KATHERINE
ROBERT EMMET	MINERAL PARK
ROCKY HILL GROUP	SIGNAL
ROOSEVELT SHAFT	SAN FRANCISCO
ROOSEVELT SHAFT	SAN FRANCISCO
ROOSEVELT#1&2	COTTONWOOD
ROSEBUD	MUSIC MTN
RUDY GROUP	ARTILLERY MTS.
RURAL	WALLAPAI
RUTH RATTAN	SAN FRANCISCO
SADDLE-BACK	MUSIC MTN.
ST. LOUIS	CERBAT
SALLY ANNE	OWENS
SAMOA GROUP	CHLORIDE
SAN ANTONIO	WALLAPAI
SAN DIEGO GROUP	UNION PASS
SAN JUAN	GOLD BASIN AREA
SANTA CLAUS PROSPECT ASSAYS (AEC #1 HAGEY)	MOHAVE COUNTY,ARIZ.
SANTA CLAUS PROSPECT ASSAYS (AEC#1 PETE)	MOHAVE COUNTY,ARIZ.
SANTA CLAUS PROSPECT ASSAYS (AEC#3 PETE)	MOHAVE COUNTY,ARIZ.
SANTA CLAUS PROJECT PROSPECTING COPPER	MOHAVE COUNTY,ARIZ.
SANTA CLAUS PROSPECT ASSAYS (AEC#2 TOM(OLD PETE#2 DPND.)	MOHAVE COUNTY,ARIZ.
SANTA CLAUS PROSPECT (AEC#2 TOM)(OLD PETE#2 DPND)	MOHAVE COUNTY,ARIZ.
SANTA CLAUS PROSPECT ASSAYS (AEC#6 TOM)	MOHAVE COUNTY,ARIZ.
SANTA CLAUS PROSPECT (AEC# 12 TOM)	MOHAVE COUNTY,ARIZ.

MINE NAME	DISTRICT
SANTA CLAUS PROSPECT ASSAYS (AEC#2 RAY)	MOHAVE COUNTY,ARIZ.
SAVANIC	BENTLY
SCHOOL SECTION	
SECRET PASS	SAN FRANCISCO
SECRET PASS GOLD TOP MINING CO.	
SECRET PASS CONSOLIDATED MINES CO.	SAN FRANCISCO
SELECT PLACER	GOLD BASIN
SENATOR	LOST BASIN
THE 78MINE	WALLAPAI
SHANNON GROUP	ARTILLERY MTS.
SHEEPTRAIL BOULEVARD	KATHERINE
SHOOTING STAR	WALLAPAI
SIAMESE GROUP	CEDAR VALLEY
SILVERADO	MAYNARD
SILVER BELL#1	MAYNARD
SILVER CREEK PLACERITAS	SAN FRANCISCO
SILVER CREEK PLACERS	SAN FRANCISCO
SILVERFIELD	MILDRED
SILVER HILL	WALLAPAI
SILVER KING GROUP	
SILVER MOUNTAIN GROUP	WALLAPAI
SILVER MOUNTAIN	WALLAPAI
SILVER SECRET	SAN FRANCISCO
SIMMONS GROUP	SAN FRANCISCO
SOUTH PILGRIM	WEAVER
SOUTHWICK VEIN	MUSIC MTNS.
STATE	COTTONWOOD
STRONG BOX	SAN FRANCISCO
SUCCESS	WALLAPAI
SUCCESS NO.S 1-4	KATHERINE
SUMMIT	WALLAPAI
SUNBEAM	SAN FRANCISCO
SUNDAY SCHOOL GROUP	WALLAPAI
SUNLIGHT GROUP	SAN FRANCISCO
SUNNY SIDE	SAN FRANCISCO
SUNRISE	
SURE SHOT GROUP	SAN FRANCISCO
SWIFT&ARMOUR EAGLES	
SWIFT GROUP	WALLAPAI
SWISS AMERICAN	SAN FRANCISCO
TELLURIDE CHIEF	MAYNARD
TELLURIDE	SAN FRANCISCO
TENNESSEE SCHUYLKILL	CHLORIDE
TIME SQUARE	WALLAPAI
TINTIC	WALLAPAI
TOM REED GOLD MINES	SAN FRANCISCO
TOWNE	
TRAGEDY GROUP	UNION PASS
TRUE BLUE-CHICO MINE	WALLAPAI
TUCKAHOE	WALLAPAI
TUNGSTEN PROSPECT	AQUARIUS MTNS.
TUNGSTEN QUEEN	CEDAR
TUNGSTITE GROUP	CEDAR
TWENTIETH CENTURY	WALLAPAI

MINE NAME	DISTRICT
21ST CENURY	WEAVER&MINNESOTA
TWINN	WALLAPAI
TYLER	WALLAPAI
TYRO	SAN FRANCISCO
UNION PASS GROUP	UNION PASS
UNITED OATMAN GOLD MINES CO.	SAN FRANCISCO
UNITED RANGE GROUP	SAN FRANCISCO
UNITED REPUBLIC GOLD MINE	SAN FRANCISCO
UNITED WESTERN	SAN FRANCISCO
VANDERBILT MINE GROUP	
VENTURE PROSPECTS	GOLD ROAD
VICTOR&OTHER NAMES	
VICTORY	WALLAPAI
VICTORIA GOLD	
VIVIAN GROUP	SAN FRANCISCO
WALDREN	CEDAR
WALKOVER	COTTONWOOD
WASHINGTON,WASHINGTON&GOLD STREAK	WALLAPAI
WEST GOLD ROAD	GOLD ROAD
WEST TREASURE	WHITE HILLS
WESTERN STAR	SAN FRANCISCO
WHEELER WASH PROSPECT	MAYNARD
WHITE CAP	
WHITE CHIEF	SAN FRANCISCO
WHITE ELEPHANT&IMPERIAL MNG. CLAIMS	WALLAPAI
WHITE HILLS	OWENS
WHITE HILLS SILVER MINE CO.	INDIAN SECRET
WICKIEUP QUEEN	
WILCOX	
WILD GOOSE	SAN FRANCISCO
WILLIAMSON PROSPECT	WEAVER
WINDY JIM CLAIMS	
WINDY POINT	MINERAL PARK
WINNAH	WALLAPAI
WOTHREE TUNGSTEN	AQUARIUS
YELLOW BASIN ASSAYS (A.E.C.#1)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(CORE&ASSAYS) (ARKLA#2)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(ASSAYS) (A.E.C.#2)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(CORE DISCRIPTIONS) (A.E.C.#3)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(ASSAYS) (A.E.C.#4)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(CORE DISCRIPTION) (ARKLA#4)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(ASSAYS) (A.E.C.#5)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(CORE DESCRIPTION) (A.E.C.#5)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(ASSAYS) (A.E.C.#6)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(CORE DESCRIPTIONS) (A.E.C.#6)	MOHAVE COUNTY,ARIZ.

MINE NAME	DISTRICT
YELLOW BASIN(CORE DESCRIPTIONS) (A.E.C.#7)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(ASSAYS) (A.E.C.#8)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(ASSAYS) (A.E.C.#9)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(ASSAYS) (A.E.C.# 10)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(ASSAYS) (A.E.C. 11)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(CORE DESCRIPTION) (ARKLA 14)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(volidation hole,core disc) (A.E.C.#A)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(LEVIATHAN ECT.)	MOHAVE COUNTY,ARIZ.
YELLOW BASIN(LEVIATHAN MINE-MILL)	MOHAVE COUNTY,ARIZ
YELLOW ROOT	HACKBERRY
YUCCA(SANTA FE)	

List subject to corrections,other additions pending

MOHAVE COUNTY BOARD of SUPERVISORS

P.O. BOX 390 • KINGMAN • ARIZONA 86401

SUPERVISOR
Donald R. Aldridge
District 1

SUPERVISOR
James H. Howell D.D.S.
District 2

SUPERVISOR
W. B. Ketchner O.D.
District 3

COPY OF LETTER MAILED TO MINE OWNERS

The Mohave County Board of Supervisors has sponsored a Comprehensive Employment Training Act (CETA) project which proposes to stimulate small and large mine activity through a review and cataloging of mineral deposits and ore reserves in the county.

The project will provide a mineral library for public use of all technical data that can be collected relating to mines and mineral deposits in this county from both private and public sources.

Our library has a file on your mine in Mohave County. We would like to have written permission from the owner and/or leasee to enter the property for the purpose of sampling mine dumps.

If preliminary testing indicates sufficient mineralization, we will cut trenches two feet deep and then cut samples for assay from the trenches. We will provide the owner or leasee of the individual dump an assay map when we do trench sampling.

We are hopeful that sufficient reserves of mine and tailing dumps can be found in the county to attract experienced capital to build a custom and toll mill to process complex ores containing lead, zinc, copper, gold and silver. It would help to give us some idea of the kind of business arrangements under which the mine dumps may be acquired: perhaps a royalty lease arrangement as one possibility and an outright sale price in total as an alternative. Neither the county nor the project will be involved in any type of mining or milling business, but we would like to be able to give experienced capital some idea of what arrangements must be made to acquire dump reserves.

Sincerely,

Donald R. Aldridge,
Supervisor, District #1

DA/VD/aj

The Mohave County Museum has ~~of~~ the originals of all these maps on file. The Dept. Mines & Min. Res has them on microfiche in Phoenix

ALPHABETICAL LISTING OF MINE MAPS FROM ROSS HOUSEHOLDER ESTATE

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack#
Ac..e Mine	12				23
Adam & Maxey Millsite			1 plan	1	19
Adams Ext. Gold Mining Co.	1				18
Adams Gold Mining Co.		4 plan			15
Adams Group	4				3
Adela Mine	2				1
Airlite Mine (Weaver Dist)	8				5 & 12
Alamo Damsite	1				5
Alamo-Signal Group	1				5
Alice Fraction					14
Alpha Group	5	4 plan			22
Alta & Signal			3 section		19
Annex Group	3				12
Antler Mines	5	1 p & s			9
A[illegible]ian-Pioneer		2 section			17
Apache Chief Group	3				5 & 21
Apache Group	2				15 & 21
Arabian Dev. Co.	4	3 p & s			15
Arabian Ext. & Finback Gr.	2				15
Arabian and Philidelphia Mines			6 p & s		18
Arabian Mines			5 p & s		18
Arabian Group				1	18
Arivada Group	1				3
Arizona Brunswick Mining Co.	1				5
Arizong Bullion Co.	1				9
Arizona Gold Mines			2 p & s		15
Arizona Group	2				3
Arizona Gypsum Group	1				26
A[illegible]izong Magma	1	8 p & s			28
Arizona Ore Reduction		1 section			28
Arizona Rand Group	5				15
Arizona Tellurium Mines Co.	1				5

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Arizona Tom Reed	10				17
Arizona Wonder Mine Co.	1				16
Arizoro Mining Co.	1				23
Assoc. Red Top Group	3				20
Atlanta & Hoffman Claims		1 section			19
Atlantic Claim			1 plan		19
B.R. Group	1				5
Badger Group	1				15
Bald Eagle Group	2				5
Banner	6	27 p & s	18 p & s		8
Banner Group	2	4 p & s			5 & 21
Barite Group	1				1
Bateman Workings			1 p & s		19
Be[illegible]er & Brethour Location	1				2
Bee-Be Group	3				28
Bella Union Group	1				28
Benton Ext.	1				5
Ben Hur-Snowball-Pioneer				1	17
Beuleeard lode claims	2	2			21
Bi-Metal Mine	3	5 plan	1		27
Bi-Metal et al.	2				10
Big Contact/Blue Dick	3				7
Big 5 and Bercuse Group	1				23
Big Four Group	5				3
Big 4 Metals Mining Co.	4	1 plan			10
Big Horseshoe Group	1				10
Big Jim Mine		6			20
Bi[illegible]im Group	1	3 plan			2
Big Spring Group	1				23
Bill Dunlap Group	1				19

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
B[illegible] Williams Damsite				1	19
Black Dyke Group	5				3
Black Eagle		4 plan			24
Black Hawk Mining Group	1				8
Black Metal Group	3				12
Black Range Group	1				16
Black Spar Group	2				16
Black Warrior Group	4				5
Blevins Moly-Lead Group	1				1
Blue Bell Group	4				13
Blue Bird Tunnel		4 plan			8
Bob Tail		3 p & s			22
Bobby Burns Group	2				28
Bobtail Basin	3				5 & 14
Bonanza	7		1 section		5
Bonanza Gril	1				17
Border States	3				21
Booby Claim	1				28
Boulder Mines Co.				3	12
Boulder Mines Incorp.	4				5
Boundary Cone Mining Co.	2				17
Brethour Group	5				2
Brighter Days Mining Co.	2	4 p & s	2 p & s		28
Brooks Gold Road Group	4				23
Buchanan-Lentz Group	1				9
Bullion Fraction	4				28
C.M. Thomas	2				5
C.O.D. Mine	11	37 p & s	9 section	4	7
C.O.D.		1 plan	1		18
Caliente lode claims	3				1
California Group	3				2
California Spray Chem. Corp.	4				19
Carbonate Mines Corp.	1	1 plan			10

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
C[illegible]r Mine (formerly Filmore)		1 section	4 section		9
Carter Gold Mining Co.		1			17
Casey Jones Group		3 plan			20
Cashier Group	3	10 p & s			22
Cedar Cons. Mines	9				9
Cedar Toll Road				1	9
Century Mine				1	10
Cerbat Golconda Section	1				4
Cerbat Section	4				4
Cerbat Group	2	2 section			4
Champion Group		1 section			18
Chapin Exploration Co.	1				5
Charity Group	1	5			14
Chicago Metals Corp.	1				10
C[illegible]ef Eng. Group	7				8
Chief Engineer Group	8	6 p & s			5
Chloride Cons. Gr.	1				28
Chloride Mining Co.	3				28
Chuck O'Luck	2				21
Clyde Vien	2				14
Comet #1	1				10
Comstock Cons. Group	4				3
Comstock Mine	1				3
Cone Group	1				16
Copper lode group	1				12
Copper Chief Group	1				10
Copperville Mine	1				9
Cross Ledge Fraction	5				17
Crown Head Group	3				17
[illegible]pel Mine	1				8
Cushman's Fraction Group	1				3
Cyclopic Mine			1 plan	1	26
Cyclopic Group	1				5

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Dardanells Group	2	6 plan			28
Dean Mine	1	1 plan			10
Deane Mine	1	2			10
Delta & Lucky Lode Groups	1				19
Democrat Group	1	1 section			10
Derek-Giant Ledge Group	1				16
Desert Star Mica Mines	1				9
Detroit Group	4				5 & 22
Dewey Group	1				17
Dewey, Ben Hur				1	17
Diamond Joe Claim		1 section			9
Diamond Joe Mine		1 section			9
Diana Mine	2	5 plan	2 section		28
Dixie Queen Group		6 p & s	4 section		12
L[illegible]ly Varden Group	1				10
Dorothy # I	1				2
Double Eagle Group	1				20
Dower Group	1				5
Eagle Group		1 plan			5
Eastern Ext. lode	2				20
Eder Group	1				5
Eileen lode claim	2				5
El Dorado Claim	1				12
El Dorado Canyon Group	1				12
El Dorado Blanket Vien			3 section		26
El Santos Mine Group	2				1
Elkhart		1 section			28
F[illegible]n L.-Alam C.	1				24
Ellenwood Group	6				21
Emerald Isle C.U. Group	3	1 plan	5 plan	1	14
Emerson Hidden Treasure	3				28
Empire Group	1				10

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Esmeralda lode	1				4
Esperanza Mine		1 section			19
Evahom Mine		5 plan			14
Excelsior Claims	1	1 section			26
Exchecquer and R.A. Claim	1				24
Federal Eastern Group	1				3
Federal Reduction & Dev. Co.	2				3
Fillmore Mining Co.	1				9
Fleck Group	1				26
Flores Group		1 section			4
Foothill Group	1				10
49er & Horn #2	1				5 & 17
Fran Van Group	4				12
Frances Tungsten Mine		1 p & s			10
French Girl Group	3				3
Frisco Mine		2 p & s		6	21
G.A.R. Mine		1			26
G.R. Mine	1				28
Gaddis and Perry	1				23
Garrison Group	3				20
Gem Group		1			9
Genuine Group	1				18
George Washington Group	3				19
German American Wash			1		17
Geronimo Gold Mine Incorp.		1 plan		2	10
Gilbert Group	6			1	3
Goethels Group	1	1 section			10
Golconda lode	1				22
Golconda Mining Co.	1	1			22
Golconda Mine	9	10 p & s		3	22

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Golconda Section	10				22
Gold Bar Group	1				4
Gold Burg Mining Co.	1				16
Gold Chain Mines	3	11 p & s		6	3
Gold Cliff Central Mining Co.	3				17
Gold Cliff Exploration Co.	3				17
Gold Coin Group		4			17
Gold Coin & Pay lode	2				4
Gold Cross #2 claim	2				16
Gold Cross lode Claim	1				5
Gold Crown Mining Co.	3				12
Gold Crown Mine	4				12
Gold Dollar Group	4				3
Gold Dust Mine		5			17
Gold Eagle (Tyler)	1	3 p & s			22
Gold Field Group	1				19
Gold Gulch Placers	6				23
Gold Key Group	4				3
Gold King Mine		1 section			5
Gold King Coalition Incorp.	1 w/viens				5
Gold King Comet #1	3		2 section		10
Gold King Mine			1section		5
Gold Knoll Mine		1 plan			5
Gold Link Group	2				21
Gold Nugget	1				4
Gold Nugget		2 section			17
Gold Ore Mining	1				23
Gold Ore Extension Group	1				18
Gold Reward Mining Co.			4		15
Gold Road Mine				2	23
Gold & Silver Mines Corp.	1				21
Gold Standard Mine Corp.			2		15
Gold Standard Group	2				19

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Gold Trail Mining & Reduction Co.	4				16
Gold Wing Dist.	1				19
Golden Cycle Group	6				2
Golden Door & Klondyke Group	4				12
Golden Door Group		2 plan			12
Golden Eagle	1	3 p & s			5
Golden Eagle #1&3	3				5
Golden Eagle Group	3				5
Golden Era Group Club	4				21
Golden Gem Claim				1	4
Golden Gem				1	4
Golden Princess Mine				2	3
Golden Rule Placers	1				21
Golden Star Mine		2 section	5 plan		14
Good Gold #1 Mine	6				16
Good Hope Group	1				5
Good Hope Mine	2	2 p & s		2	22
Grace Group	4				12
Grande Berg Silver Mines Co.	1				4
Grandma Cons. Corp.	1				18
Grannis Group	1				18
Great Bends Mines Co.	1				18
Greenwood Section of Owens	3				1
Grey Eagle & Big Jim Mine	1				20
Grass Copper Group	1				14
H.E. Smith Group	2	2 plan			4
Hamilton Mine	1				28
Harold Group	1	4			17
Harold Mine		1			17

Mine	Claim Map	Underground Map	Underground Assay Map	Misc. Map	Rack #
Hartman Gold Mining Co.	3				20
Hayes Nevada	4	2 p & s			4
Hazel Group	2	4 section			17
Hedrick Group	3				13
Helen May Mine	1				5
Henry Ford Group	1				23
Hercules Group	1				16
Hercules Katherine & Patty Fragments	2				3
Hibernia Group	5				9
Hibernia Tunnel		3 plan			9
Hidden Treasure Group	1	3 plan			28
Hidden Treasure, Irvin, Comm., Harold		1			17
Highland Chief Tunnel of the Highland Chief Mine		2 section			16
Highland Chief Group	2	2 section			16
Hollywood Katherine Group	1				3
Holy Moses Mine	1	1 section			10
Home Pastime Mine		2 p & s			14
Homerun lode	1				20
Honey Bee Group	2				3
Horn Silver-Oxident		1			26
Horseshoe No.1 Mine	1				20
I.X.L. Mine	4	6 section	6 section	1	7
Iguana Group	1				9
Illinois Katherine Mining Co.	7	3 plan			2
Independence Mine Group	1				13
Iowa Group of Mines	1				16
Irving		2			17
Irving, Harold, Runover, Treadwell		2			17

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
J.C. Mine					4
J.R. Group	2				28
Jack Pot Group	2				28
James Group	2				23
James & Martin Group	2				23
Jim Kane		2			4
Johnny Bell Group	1				21
Johnson Group	5				3
Jumbo lode	1				1
Juno Mine			1 plan		28
Justice Group	3				12
Kampff & Fredricks	1				19
Kaaba Mine		8 p & s			10
[illegible]ne Mine		2 p & s			4
Katherine		2 plan			5
Katherine Claim		1 plan			5
Katherine Pat. Claim Group	1				3
Katherine Gold Dist.	23				13
Katherine Group	1				2
Katherine sec. of Union Pass Dist.	7				2
Katherine Ext. & Katherine #2	1				2
Katherine Ext. Mining Co.	1	1 plan			2
Katherine Gold Dist.	3				18
Katherine Ext. Underground	1				2
Katherine Ext. Group	1				2
Katherine Eastend Gold Mg. Co.	1				2
Katherine Florence Group	6				2
Katherine Rand Mines Co.	3				2
Katherine-Victor Mining Co.		1			3
Katherine Section		1 section			3
Katherine Sunbeam Group	2	1 plan			2

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Katherine Union Pass	3				18
Kay Group	1				14
Kempercamp of the Utah & Assoc. Golden Copper Co.		2 plan		1	12
Kent Russell Group	1				3
Keystone Tunnel.	2	3 section	5 plan		14
King of Secret Pass	3	3 section			13
Kingman Mining Co. and E.A. Chase Placers	1				10
Kingman Gold-Lead-Silver Merger Mines Co.					5
Klondyke Mine		1 plan	4 section		12
Lady Group	2				2
Larry R. Mine	1				23
Lazy Boy Group	1				16
Lead Mt. Tunnel	3				8
Lester Claim		1 section			26
Leviathan Mine		3 plan			9
Lexington	2	3			16
Lexington Mine Group	2				16
Lillian	1				26
Little Boy lode Claims	13				25
Little Chief Workings		3			8
Little Jim	1				18
Little Johnny	1				1
Little Judge Group	1				2
Little Wonder Group	3	3 plan			19
Lluvia De Oro Mine	1				21
[illegible]ning & Join Me Groups	1				21
Lorena Oneida	2				8
Lorena # 1 & 2	1				8
Lost Mine group	1				1
Lucille #2 of the Utah, AZ		1 section			12

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Lucky Bill Group	4				5
Lucky Boy Group	3				2
Lucky Boy Mining Co.	2	1 section			28
Lucky Star Claim & Mustang	3				11
Lutie Claim		1 section			26
Lutie Mine Group	1				16
Malick Group	2				14
Malik's Golden Age Group	8	1 section			12
Mamouth Cons. Mines		1 section			10
Mandalay Group	1				18
Manuel C.I. Fuentes Group	1				14
Marian Claim	2				10
Mariposa	2				18
Mary Bell	1				
Mastadon Claim	1				9
Maxine Mining & Milling Co.	3				10
Mayflower Group	2				5
Mazona Group	5				17
McBride Mines	6				1
McCrakin Hill Mines	8		1 plan		19
Meals Mining & Milling Co.	6				23
Meals & Record Group	1				23
Merlo Mica Mining Co.	8				10
Merritt Group	1				20
Midnight Cons. Mines Co.	1				17
Midnight Group	1				13
Midway lode claim	1	1 plan			23
Midway Group	6				3
Mike Coleman Properties	5				13
Miller Group	2				3
Minneapolis Group	2				17

Mine	Claim map	underground map	Underground Assay map	Misc. map	Rack #
Minne lode			1 plan		21
Minnesota Connors Mine	3				5
Mines Operative Corp.	1				18
Mohave Gold Hill Dist.	1				19
Mohave Mohawk G.M.	1				21
Mohave Butte Gold & Copper	2				17
Mohave Gold Mining Co.	1				12
Mohawk	1				5
Mohawk #2	1				5
Mohawk Ext. Group	4	5 section			2
Mohawk Indian	1				2
Mollie-Lead Millsite	2				9
Monte Cristo Tunnel		1 plan			14
Montezuma Placer Gr.	1				18
Moon Group			2		14
Morning Star Group		6 section		2	8
Moss Ruth Rattan Area	4				23
Moss Mine	1	1 p & s	7 section	1	23
Moss Group	1				23
Mossback Ext. Group	2	5 p & s			23
Mrs. Kay Group	1				14
Nancy Lee Mining Co.	3				13
Narrow Gauge		1 section			26
Nellie Mining Co.	1				16
Nevada Fraction lode	4				3
Nevada Group	6				3
Nevada Standard	2				23
New Comstock Group	2		1 plan	1	2
New Discovery Group	2				3
New Jersey Mine		1 section			28
New Moon Group	7	1			14

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Ne[illegible]atime Group	2				3
New Mine Group	1				17
Norma Mine		1 section			26
North Aztec lode claim	5				20
North Georgia Claim	1				28
Northern Cons. Group	3				12
O'Fallon Mine	1				7
OK Mine Group	2				5
Oatman Amalgamated G.M.Co.	13				23
Oatman Apex Gold Mines Inc.	4				20
Oatman Gold Dist.				1	17
Oatman Eastern Mining		2			17
Oatman Eureka	6	1			17
Oatman Federal Mines Co.	1				3
Oatman Hilltop Group	8				20
Oatman North Star Mines Co.	2	2 section			20
Oatman Revenue Group	2				3
Oatman Southern Mining Co.	1	1 plan			16
Oatman Secret Pass Gold Mines	2				13
Oatman United Gold Mining	4				20
O'Brien Mine Groul	2	2 section	6 section	3	4 & 5
Old Colony Mines Ltd.	3	8 section			8
Old Dad Tunnel		11 plan			9
Old Gold & Chemehuevis Red Hill Placers			1 plan		19
Old Timer Group	4				2
Onetto Group	1				23
Optimo Claim	1				28
Oregon Group	2				3
Original Mine Group	1				21
Original New London	1				24

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Orion Mining & Milling	1				11
Oro Plata Mine	1				5
Osterman Placers	1				10
Overlook Claims		2			2
Owens Mining Dist.	2				19
Oxident & Horn Silver Mines		1			26
P & M Mining Co.		1 plan			1
Pacific Group	1				23
Parker Hibernia Group	2				9
Pavell Mine		3 p & s			22
Paymaster	2				5
Paymaster Group of Mines	2				4
[illegible] Roll	1				5
Peerless Mines Devel. Co.	10				8
Perlite Group	2				5
Pilgrim Gold Dist.	5				12
Pilgrim Gold Mine		8 p & s			12
Pilgrim Group	1				12
Pilgrim Mine	2	19 p & s	5 p & s	4 assay	12
Pioneer Ext. Claim	5				12
Pioneer Gold Mines Co. Gp.	3	3 plan		3	5
Pioneer	3	12 p & s	1		17
Platoro Group	1				23
Pontiac Mines	2				22
Portland Mine Group	4		3 plan		12
Post Group	1				23
Prince George Works		2 p & s	4 p & s		8
Principle Mining Group	1				11
Puzzle Group	2				28
Pyramid Group	1	4 p & s			2

Mine	Claim map.	Underground map	Underground Assay map	Misc. map	Rack #
Queen Bee Group	3				14
Queen Katherine Mine	1				2
Queen of May	5				28
Rattlesnake Group	1				18
Radio lode claim		4 section			12
Rainbow Group		1 section	9 section		28
Rawhide Group	2				19
Reco Group	1				20
Red Bird	1				20
Red Crown Mines	8				13
Red Gap Group	1	2 plan			12
Red Hill & Red Hill Ext. Gr.	2				21
Red Point & No. Name Groups	1				16
R[illegible] Top Group	3				20
Redemtpion Mine	3				20
Revenue Eastern Mines Co.	1				3
Revenue Mines Co.	1	1 plan			3
Rice Bird (Sautate)	3				17
Riverview & Riverview I	3	4 section			21
River Range Annex Group	2				2
Roadside Mine	2	1 section			3
Rosebud Mine	1				1
Round Top Group	2				26
Round Top Claim	2				26
Ruth-Rattan Mine				1	20
S.W. Bismuth Group	2				1
S[illegible] Francisco Group	9	1 p & s			9
San Francisco Mining Co.	1				20
San Juan Group	1				26

Mine	Claim map	Underground map	Underground Assay map	Mics. map	Rack #
Sa[illegible] Fe Gold & Silver Mines Inc.	1	2 section			10
Sayer-Lola Group	2				19
Schaffer's Treasure Mine	1	1 p & s			26
Schnectady Group	3	2 plan			28
Secret Pass Mining & Milling	1				13
Secret Pass Gold Top Group	13				13
Seviers Minerals Co. Group	3				4
Sell Mine	1				5
Senator Mine			2 plan		19
Seneca & Oneida South	1				8
Sheeptrail Boulevard Mines Co.	5	10 p & s	7 p & s	5	21
Shoestring Group	3				12
Siamese Group	1				9
Side Issue	1				5
Si[illegible]a Blanco Group	1				14
Signal-McCraken			1 section		5
Signal Mines		2 section	1 plan		19
Signal & Alta Mines		1 section			18
Silver Streak Claims	1				19
Silver Bell Claim	1				14
Silver Bell Group	1				10
Silver Creek Bonanza Co.	13				5 & 23
Silverado Group	5				10
67 Mine	1				26
Snowball Group	3				17
Sorora Group	2				3
South McCraken Group	1				19
Southern Gross Group	3				2
So[illegible]h Pilgrim Mining Co.	3				12
South Sudley lodes	2				8
Spider Group	1				17

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
St. Louis		10 sections			4
Standard Minerals Mine		1 plan			10
Stella Group	1				1
Sugarman & others	1				
Sunbeam Group		1 plan			2
Sunlight Group	3				21
Summit Mine	1	12 p & s			22
Sunnyside Ext. Group	6	2 plan			16
Swift Armour Claim	9				7
Syndicate Porphyry Gr.	2				14
Tango Group	1				23
Taylor Mine Group	3				5 & 18
Telluride Mine		1 plan			17
Tennessee		1 p & s			5
Thia Court Group	1				16
35th Parallel Claim		1		1	17
Thumb Butte	1	6		2	15
Times Mining Co.	6	5 plan			20
Tintick Mine		3 plan	1		28
Tin Cup		6 section			13
Todd Mine	1				18
Tom Reed Gold Mines Co.	2				5
Tom Reed Gold Road Dist.	31				11
Towne Mine	4	1 section	5 section		28
Treadwell Mine	1	1			17
Treasure Vault Gold Ext. Inc.	3				2
Treasure Hill Coalition Mines	2				8
Treasure Vault Pilgrim	1				12
Trio Mining Co.		2 section			18
Tuckahoe Mine		1 p & s	2 section		28

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
20th Century	1				5
Twins Mine	2	2 section			4 & 24
Tyro Mine	3				21
Uncle Sam Group	6				21
Union Pass Mining Co.	2	1			3
Union Scarlet Mine		2 plan			16
Union & Secret Pass Sec. of Wallapai Dist.	1				5
United American Mine		2 plan			20
United Eastern Mining Co.			1 section		20
United Republic Group	1				16
United Republic Gold Mining Co.	4	3 plan	1		16
United Republic Mine	1	2 section			16
United Western Mine	6	7 plan	1		20
Uranium Corp. Group	2				22
Vandover Claim	1				9
Victor Copper Co.	6				10
Victor C. Walters Group	2				16
Victoria Gold Mines Inc.	5	26 section	1	2	16
Victoria Gold Mines Co. Gr.	4				5
Visnaugua & Somehit Frac.	6				20
Vivian Mining Co.	2				17
W.A. Brooks & Kennedy Gr.	1				23
Wallapai Dist.	1				4 & 5
Wallapai Copper Co.	1				10
Wallapai Group	1				14
W[illegible]aw Claim	1				12
Wayne Mica Mine Group	3				10
West Cons. Copper Gr.	1				28

Mine	Claim map	Underground map	Underground Assay map	Misc. map	Rack #
Western Amer. Gold Inc.	2				3
Western Apex		1 p & s			20
Western Star Mine		2 section		2	23
Wheatons Claim	1				23
White Eagle Group	3				5
White Eagle (C.O.D.Sec.)	6		3 section	2	7
White Elephant	1				4
White Hills Mining Co.	1				26
White Hills Silver Mines Inc.	1				18
White Horse Group	1				14
Wilard Group	2				16
William S. Murray Prop.	2				28
Williams Tungsten Group	1	3 plan	1 plan		19
Winchester & Jublee Mine	3				8
W[illegible]sor	9			4	28
Windsor Mine (Wall. D.)	2				5
Wright Creek Mining Dist.	3				1
Wright Gold Mines	1				1
Wrigley Exploration Co.	1	1 section			16
Wrigley Sulfide Mines	1				8
X ray Group		1			28
Yellow Aster Group	1				17

ALPHABETICAL LISTING OF MINERAL SURVEY PLATS IN MOHAVE COUNTY

APPENDIX F

Procedures for Sampling Mine Dump

1. Establish mode of dumping to extent possible.

2. Lay out sample trench grid with straight lines as parallel as possible to the dumping pattern.

3. Remove at least two feet of surface in trench on the grid line.

4. Gather (or cut) sample with a #2 longhandled, round point shovel from the bottom of trench using care to collect equal portions from each running foot of the trench. Where the sides of a trench cave across the bottom, clean out the caved material by hand before cutting the sample. The probable weight of sample should be from 100 to 400 pounds depending on length of trench.

5. Establish and mark a sample interval for each dump grid (trench) consistent with the size and shape of the dump, but to be not less than 10 feet nor more than 200 feet.

6. Weigh total sample and record.

7. Screen the sample over a 2-inch screen.

8. Weigh the plus 2-inch material and record its weight to the nearest pound and discard.

   a. Screen the minus 2-inch material over 1/2 inch screen
   b. Crush the minus 2-inch plus 1/2 inch to minus 1/2 inch.
   c. Mix the sample thoroughly on a mixing cloth and run through splitter until whenever possible, there is about 75 pounds of sample remaining. Continue to split until there is about 5 pounds to be sent to the assay office.
   d. Sack and tag the sample for assay. Write on the tag the mine or dump name, the sample number, the length of sample cut and the metals identified for assaying on the tag.

9. Not over 70 pounds of the rejected material from step 8c will be sacked and tagged identical to 8d and stored for metallurgical testing.

10. Weigh one cubic foot of the dump material being sampled.

11. Establish survey control and survey grid trenches and sample intervals by stadia method. Run stadia survey of where dump intersects natural ground and the toes and crests of the dump. Shoot any low or high points on the surface of the dump.

12. Make an assay-volume map using above measurements.

APPENDIX G

Procedures for sampling tailing dump

1. Check tailing area closely to see if there has been any horizontal segregation of the tailing with relation to metallurgical treatment, such as jig tailing, leach or flotation tailing, etc.

2. Establish a sampling grid for each segregated part of the dump, preferably parallel to the horizontal confinement of the segregated part of the dump to be sampled. Stake and flag those points where auger holes are to be sunk.

3. Survey in each hole on the dump and toes and crests of the dump, as well as the points where the surface of the tailing intersects a canyon wall where the tailing pond is in a canyon.

4. Pull the auger each one-foot of depth, and dump the auger on a sample cloth.

   a. Segregate the sample at any depth where a definite color change occurs.
   b. It may be necessary to dry entire sample before splitting and mixing.
   c. Mix the sample thoroughly by rolling the sample cloth at least 10 times.
   d. Run total sample through splitter until reduced to approximately a five-pound sample.

5. Sack the sample to be assayed and sack not more than 70 pounds of the sample rejects for storage and metallurgical testing.

6. Place tags on both the sample and sample rejects. Write on both tags:

   a. Name of mine or mining claims.
   b. Name of tailing dump if other than the name of mine or claim.
   c. Sample hole number with capital T in front.
   d. Length of sample interval in hole footage: i.e., 15-25 feet
   e. Assay for Au, Ag, Pb, Zn and/or Cu, or other appropriate elements.

7. Make a hole log sheet showing:

   a. Name of mine, claim or tailing dump
   b. Number of samples.
   c. The hole footage in each sample
   d. Total depth of hole
   e. Metals to be assayed
   f. and any irregularities in the hole such as sticky clay at footage or course sand from 30 to 40 feet, etc.

8. Transport sample to laboratory and the retained sample rejects to storage.

9. Establish local survey control without benefit of public land survey unless convenient. Survey by stadia method all auger holes, toes and crests of the tailing pond, points where the top of the dump intersect mountain slopes where the tailing is confined in a canyon, and all high and low points on the surface of the tailing.

10. Make an assay-volume map from above measurements.

Plat Book Index

MS#	Claim Name
3671	A.B.
3011	Alabama
3782	Albert
3006	Alice B.
3585	Alma C.
3041	Alpha
3845	Alta
4129	Alta
659	Alta Claim
3408	Ambassador
3408	Ambassador no. 1
3361	Anax
3191	Andy lode
3300	Annie
3333	Antimony
2822	Antimony
2822	Apex
3363	Arizona (Sec.3 T23 R18)
4118	Arizona Bill
3670	Arizona Central
3301	Arizona lode
3876	Arrowhead
2534	Atlanta
3871	Atlantic
1575	Aztec
3845	Aztec
3199	Aztec Center
3199	Aztec Center SE
3671	B.A.
4137	B.C.C.
3805	Baby Katherine
3199	Bald Eagle
3888	Banner
2533	Beaver
2610	Benjamin Harrison
3671	Beryl
2610	Bessel
1368	Beuleeard
2987	Big Bethel
3400	Big Boy lode
3264	Big Dam
4118	Big Sight
3282	Bill Rush #1
3282	Bill Rush Fraction
1699	Billy Bryan
2750	Bi-Metal
3956	Black Eagle
3956	Black Eagle Annex
3508	Blackfoot
3871	Black Hills
4345	Black Jim
3508	Black Metal
4009	Black Prince
3842	Black Talc
3956	Black Warrior
3342	Blue Bird
3505	Blue Ridge, Blue Ridge Ext. Blue Ridge Frac
4576	Blue Ridge Home lode
1102	Boana Vista
2822	Boer
2872	Booby
2460	Broken Hills
2531	Brooks
3571	Brunswick
3571	Burnswick no. 1
3375	Buckey O'Neil
3520	Bullion S. lode
3190	Bunker Hill
3780	Bunker Hill
3520	Burlock lode
3694	Buster lode
3361	Butte
4118	Caledonia
3876	Calico
4028	California
4028	California #5
182	California Moss lot 37
796	California Moss lot 38
2993	Central
3571	Century
1689	Champion
4209	Chapin no.'s 4,5,6,7,8,9,15,16,17,18,19,20
2431	Christmas
3271	C.J.D. no. 2 and C.J.D. no. 3
2065	Clark
2854	Clearing House
3573	Cleopatra
1699	Climax
3871	Club
3845	C.O.D.
3671	C.O.D. Jr. no. 2
3671	C.O.D. Jr. no. 3
3671	C.O.C.
3871	Colorado
2240	Comet
3565	Combination
3565	Combination Fraction
1639	Commission
2904	Cone View
2904	Cone View # 2

3670 Congress no. 2
3188 Consolidated
3333 Copper
3375 Copper Bar
3375 Copper Bar no. 1
3527 Copper Canyon
3102 Copper Con
3171 Copper Giant
3102 Copper Glance
3375 Copper Glance
3508 Copper King
3290 Copper Wonder #1
3290 Copper Wonder #2
3375 Copper Wonder
3527 Copper Wonder #3
3527 Copper Wonder #4
3527 Copper Wonder #5
3871 Coronado #1
3871 Coronado #2
3871 Coronado #3
3871 Coronado #4
3006 Cottonwood Springs Millsite
103 Cupel
3188 Daisy Fraction
3612 Daisy Twins
3264 Dam Site
1456 De La Fountaine
3782 Del Rey
3782 Del Rey no. 1
3782 Del Rey no. 2
1639 Dewey
2869 Dip
3638 Dorothy
3638 Dorothy #1
3408 Dragoon
3188 Eastern
4055 Eileen
1639 Eleanor
4136 Ella Metchell
3585 Ellen L.
3300 Emma lodes
3706 Ensign lode
1215 Esmeralda
4055 Ethel
4210 Evening Star
2779 Exchequer
1810 Fair View
3565 Falcon

4136 Fall no. 4
3320 Flores North
3320 Flores North #2
3320 Flores West
2874 Foothill
3005 Fortunatus
3508 Fraction
3956 Fraction
1699 Gambler
2704 Giant
3006 Gladys
3671 Gladys
2617 Golconda lode
2426 Gold Coin
2704 Gold Cross
2869 Gold Crown
1699 Gold Dollar
1699 Gold Dollar Ext.
2869 Gold Dome
1602 Gold Dust
3427 Gold Hill
3333 Gold lode
2832 Gold Nugget
3300 Gold lode
2832 Gold Nugget
3300 Gold Range Ext.
3845 Gold Ranger
3300 Gold Range Fraction
3508 Gold Reserve
3317 Gold Road View
1699 Gold Road
4136 Gold Road West Ext.
3842 Gold Trail
3427 Gold Wedge
1101 Goldbug no. 2 lode
2426 Golden Eagle
3294 Golden Eagle lode
2512 Golden Era
1287 Golden Gem
3888 Golden Eagle
3871 Golden Lily
3614 Golden Queen
4142 Golden Treasure
4142 Golden Treasure Fraction
3282 Good Gold #1
4210 Goodluck
4210 Goodenough
3707 Grant lode
1810 Gray Eagle

2526 Grey Eagle

2822	Great Eastern Ext.
2822	Great Eastern
3188	Great Western
3614	Green and Gold
3506	Green Linnet lode
3199	Grey Eagle
1639	Harold
3695	Hawk lode
3342	Hawkeye
1575	Hazel
3871	Helen
1639	Hidden Treasure
1810	Hidden Treasure
2431	Hidden Treasure #1
2431	Hidden Treasure #2
2716	Hidden Treasure Ext.
3168	Highland Chief
3594	Highland Chief
3427	Hill lode
3361	Hillire
2833	Hillside View
3845	Hobo
4146	Home Run
2670	Homestake
3497	Homestead
3497	Homestead #3
3497	Homestead #7
3251	Horseshoe
3251	Horseshoe #1
3251	Horseshoe #2
1699	Houghton
3638	Howard
3006	Ida
2460	Idaho
3976	Inchilario
3876	Inchilario Ext.
3282	Index no. 4
3282	Index no. 5
3282	Index no. 6
3282	Index Fraction
2669	Indiana
3671	Innes
2240	Iron Rod
1639	Irving
3251	I.W.W.
2670	Jack Pot
3782	Jackson
3171	Janie
1680	J.B. Lane
3573	Jefferson Mine
3709	Jimbo lode
3368	Johnny Bull
1315	Jub lode
2854	Jubilee
4118	Jumbo
3565	Jumbo
3600	Juror no. 1
3600	Juror no. 2
2249	Kansas Girl
3814	Katherine View no's 1,2,3
3814	Katherine View Frac. no's 1,2,3,
4017	Katherine Ext.
4017	Katherine Ext. #2
3266	Katherine lode
3638	Katherine Millsite
3102	Kennedy
3171	Keystone
3573	Keystone
3171	Keystone Ext.
2869	King Edward
3814	Kit
3845	Kokomo
3845	Kokomo #1
3845	Kokomo #1
2512	L & R
3408	La Puerto De Oro
3782	La Veta Verde
3782	La Veta Verde no 1
1368	Lady Bright
3761	Lady Bright #1
2440	Last Chance
3565	Lazy Boy
3333	Lead
1680	Leland
1680	Leland #2
3290	Leviathan
3290	Leviathan Millsite
3876	Leviathan
2870	Lilah
1699	Line Road
3361	Linkbelt
3011	Little Annie
3188	Little Jimmy
3814	Little Johnny
3871	Little Lily
4210	Little Luph
3375	Little Midnight
3565	Live Boy

4137	Lizzie Lemen
3505	Lodestone, Lodestone no. 1
3966	Lola
3235	Lonesome
3876	Lonesome Pine
3484	Lotus lode
3300	Louise Fraction
3122	Lucknow
2671	Lucky Guss
3876	Lucky Spot
3102	Mackin
3102	Mackin no. 1
4210	Madeline
3594	Madrid
3041	Magnolia
3594	Malone
2065	Mary Ellen
1639	May Dickson
3114	Mayflower no. 1
3300	Merrill
2065	Midgen
3557	Midnight
3888	Midnight
4137	Midnight
2750	Mineral Point
3361	Mingis
2426	Minneapolis
2426	Mineeapolis #2
1368	Minnie
1680	Mitchell
2249	Mohave
2872	Mohawk
3122	Mohawk
3237	Mohawk
3237	Mohawk Ext.
3847	Mohawk Ext. no's 1,2,3,4,5,6,7,8,9
3985	Mohawk Ext. no's 10,11,12,13,14
3871	Mojave Peak no. 2
3871	Mojave Peak no. 3
3871	Mojave Peak
3871	Mojave Peak no. 1
3363	Montana
3871	Montana
3508	Montreal
3782	Monday
3567	Monhatton lode
4210	Morning Star
3508	Moscoe
3006	Mossback
3006	Mossback Ext.
2833	Mountain Top
3188	Mountain View
3122	Music no. 1
3122	Music no. 2
3122	Music no. 3
3122	Music no. 4
3122	Music no. 5
3122	Music no. 6
3122	Music no. 7
3122	Music no. 8
3122	Music no. 9
3122	Music no. 10
3122	Music no. 11
3122	Music no. 12
3282	Myron Z
3282	Nellie
3282	Nellie #2
3282	Nellie #3
3506	Nest lode
3565	Never Rest
2833	New Comstock
4136	New Year
3871	Newsboy
2704	New York
2567	New York lode
3235	Nightowl
3782	No Name
3782	No Name no. 1
3845	North Aztec
3497	North Hackberry #2
3497	North Hackberry #3
3497	North Hackberry #4
3188	North Parallel
3122	North Star
2610	Olla Oatman
3041	Omega
3575	Oneida South
2669	Oregon
1680	Oro Fino
2750	Oro Fino
2532	Otsego
2122	Oversight
3871	Pacific
3717	Pasadena no. 1 through no. 6
4009	Pay Roll
641	Peabody Claim
1575	Peacock
3520	Peggy lode
3342	Pelican lode
3255	Perry
1215	Phantom
3961	Picnick
3695	Pigeon lode
3842	Pilot Knob

1639	Pioneer
3285	Polaris
3757	Portland
3339	Primrose lode
4017	Princess Katherine
3496	Protection
2869	Protection
3496	Protection #1
3496	Protection #2
3640	Pyramid Millsite
3264	Pyramid Rock Codes
2779	Quaker
3670	Queen Bee
3805	Queen Catherine
4055	Queen
2440	Railroad
4118	Rancee
3361	Ranger
3361	Rangers Ext.
857	Rattan Mines
1104	Rattlesnake
3102	Ray
3102	Ray no 1
2779	R.A.
3565	Red Bird
3573	Redbreast
4137	Red Creek no. 1
4137	Red Creek no. 2
3188	Red Cloud Ext.
1368	Red Hill
3782	Red Point no. 1
3782	Red Point no. 2
2776	Red Seal
1680	Release
4118	Relief
1810	Rene
3361	Review
3255	Resaca
3267	Rice Bird
3255	Rising Fawn
2610	Rising Star
3876	Roadside
1699	Robbie
2749	Roosevelt
3122	Roosevelt
3573	Roosevelt
3888	Roving Dick
3319	Royal B B lode
3871	Royal Lily
3876	Ruby Silver

1639	Run Over
2213	Ruth
3956	Sacotash
3361	Saddleback
3361	Saint Valentine
3028	Salt Spring
1810	San Francisco
657	Senator Claim
3575	Seneca
1368	Sheeptrail
3102	Shorty Ditto
2833	Side Hill
3361	Sideline
3333	Silver
2987	Silver
3011	Silver Bell
1699	Silver Dollar
3368	Silver Knight
2776	Siwash
3451	Sky Scraper
1639	Snowball
3573	Somerset no. 2
3782	Southside #1, Southside #2
3842	South Gold Trail
3845	South Oversight
3871	Spade
3294	Spanish Treasure
3188	Standard
2869	Standard
3196	Starlight
4137	Stip Fraction
2854	Stockton Hill
3188	Stray dog
3290	Summit
3290	Summit Millsite
3285	Sun Dial
3285	Sun Rise
3757	Sunshine, Sunshine no. 2
3708	Sun Shine
3888	Sunnyside
3426	Sunny Side, Sunny Side Ext. Sunny Side Ext.
3361	Sunbeam
3285	Sunset
3188	Sunset
3888	Sunset
3188	Sunrise
3708	Sunshine
2598	Sunshine, Sunshine #2, Sunshine Millsite
2822	Surprise West Ext.
2822	Surprise
2822	Surprise East Ext.

2854	Teddy
3342	Templar
3505	Telluride #1, through #5
2669	Texas
3845	Three Square
1699	Tip Top
2710	Tip Top
2240	Tom Tit
3188	Tom Reed Ext.
3188	Tom Reed Ext. #2
3300	Tonopah no. 1
1639	Treadwell
3235	Treasury Fraction
3235	Treasury
2870	Trio
2653	True Blue
1575	Turquoise King
1575	Turquoise Queen
3670	Tunnel Site
3321	Tungsten no.'s 1,2,3,4,5,6,7,8,9,10
3285	Twilight
3956	Twin Basin
3612	Twins Ext.
3612	Twins
2426	Twin Cities
1639	35th Parallel
3011	Uncle Sam
3961	Uncle Sam Fraction
3288	United Western
3288	United Western #1
3288	United Western #2
2502	Vanderbilt
4136	Velvet
2243	Victor
3171	Victoria
2243	Victor
3171	Victoria
2243	Virgin
2889	Virginia
1679	Vivian Mine
3670	Wakeup Jim
3041	Wallapai Queen
3871	Washington
1680	Water
3290	Water Claim lodes
3876	Water Lily
3876	Water Fall
4118	Wedge Point Fraction
4136	Wedge
2833	Western Scene
3876	Whale
3290	Whale
3290	Whale no. 3
1680	Whaleback
2869	Watchman
3300	Wheeler
3300	Wheeler Fraction
1575	Wheetman
3573	White Horse
3317	Wild Goose Fraction
3871	Wild Lily
3361	Wildman
3638	Wilson
2854	Winchester
3782	Windy Point
4055	Wonder
3638	Woodrow
3871	Wyoming
3300	Yankee
4379	Yellow Bird & Yellow Bird Millsite
3011	Yellow Girl
4379	Yellow Root & Yellow Root Millsite
2915	Yellow Leader
3190	York
3190	York Annex
3876	Zero West
4137	Zoroaster

2/4/77

MISC. MAPS IN PLAT BOOK

1. Partial old blueprint map of Oatman area nil no.
2. Hays Copper Group (3miles to 5 miles of Needles, Calif.) nil no.
3. Coconino County, Mugwump-Arizona Jim-etc. no.1655
4. Coconino County, Warm Springs millsite no.1668
5. High Jolly Claims T3N R20W Sec.6
6. Fracil Township 22N R6W G&SRM Ariz.
7. Music no.1 etc. sheet no.1 T26N R15W MS#3122
8. Top and Union Basin Mines(claims)
9. McKinley Group, Cerbat, Arizona
10. Cupel Secs 4 & 9 T22N R17W Lot.no.37
11. Township 22N R17W (plat)
12. Supplimental plat Sec.17 T26N R15W
13. T28N R18W (plat)